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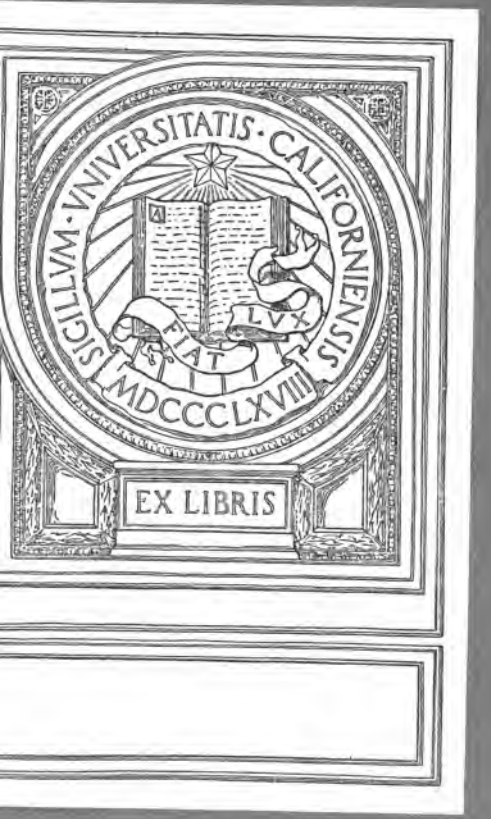

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PROCESSES OF FLOUR MANUFACTURE

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PROCESSES OF
FLOUR MANUFACTURE

BY

PERCY A. AMOS

HONOURS SILVER MEDALLIST, CITY AND GUILDS OF LONDON INSTITUTE
HONOURS SILVER MEDALLIST, NATIONAL ASSOCIATION OF BRITISH AND IRISH MILLERS
LECTURER ON MILLING (FLOUR MANUFACTURE) AT THE MANCHESTER
MUNICIPAL SCHOOL OF TECHNOLOGY

WITH 117 ILLUSTRATIONS

NEW IMPRESSION

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PREFACE TO SECOND EDITION

In revising this edition, the Author has endeavoured to include all the latest and most important developments of the industry, both in machinery and in manufacture. The main text being so recent, has little need of much alteration, but data and prices, etc., have been brought up to date. Corrections have been made where changing practices have rendered them necessary. The latest lists of the world's wheats will be found useful. As to the prices and quantities quoted it has been judged better to deal with the normal times just previous to the European War now raging. For a time these details will be greatly altered, but will eventually become normal, and are the only safe figures upon which to work. Roller mills have received more attention deservedly, and several illustrations have been added which could not, unfortunately, be included in the first edition. Plansifters are still increasing in favour, and have been dealt with more fully both in the illustrations and in the text. Several additions to the bleaching and stock treatment process have been made.

Every effort has been made to include matters of first importance in the work of milling.

It is hoped that these will render the second edition of even greater assistance to the student and the working miller than the first.

The Author feels that he must pay a word of tribute and admiration to our Fleet. All millers realise at this time (as the public do not), that but for the untiring vigilance and determination of our Navy, a partial blockade might have been established by Germany, sufficient to diminish seriously our all-important over-seas wheat supplies, and bring about a state of starvation and misery dreadful to contemplate.

The Author wishes again to thank all those friends and firms who have helped to make the book a success.

PERCY A. AMOS.

April, 1915.

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PROCESSES OF FLOUR MANUFACTURE

CHAPTER I

INTRODUCTION

In placing this text-book before the milling public, a brief statement as to its scope and aims will be advisable. To those in touch with Schools and Institutes throughout the country, the one surprising thing is that so few attempt to start classes or lectures on the subject of flour milling. In view of the fact that the industry is a vast and important one, and that it has a distinct bearing upon the health and well-being of the British public, this state of affairs is to be deplored. No doubt one reason for this is that the number of men employed, directly or indirectly, in the trade is quite out of proportion to the enormous output of flour and offals, but at the same time, in large centres, a series of lectures by competent men would be appreciated by those actively employed in the mills, and by those whose connection is quite distant, but who have an interest in the matter. The author has had experience, during a series of lectures, delivered at the Manchester School of Technology, upon this subject, and included in the class have been screenmen, milling operatives on the various machines, warehousemen, mill clerks, foremen, milling apprentices, flour salesmen, and travellers, and even provender millers. Those only casually acquainted with the industry have invariably expressed surprise and admiration for the elaborate storage, cleaning, conditioning and milling systems of modern mills, and have admitted that the many prejudices which they shared with the general public have received severe shocks in the light of the facts. The English miller has many severe and oft-times unjust criticisms passed upon him by the public generally, who in most cases are quite ignorant of the elaborate means employed to supply pure flour from a wide range of wheats. Contamination and degrading of the finished products by matter originally contained in the wheat has now been reduced to the vanishing

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point, thus making for purity and the full nutriment of the valuable food-stuff contained within the wheat berry. What is wanted for a sound health-food is good strong white flour, not too fine or too white. The recent swing of the pendulum to the "grey" 80 per cent. "standard" flour has been really brought about by the public themselves. For years they have been demanding very white bread and very white flour. The bakers had to comply with this, or lose their custom. They in turn, therefore, had to demand from the millers the fine white flour. The high cover numbers on the dressing machines resulted in the most valuable particles of the flour being partly eliminated, *i.e.* those containing gluten, which naturally remain with the coarser flour. The public therefore got starchy, weak flour, robbed of a lot of nourishment, and presently began to cry out for whole, or partly whole, meal, whereas by being content with creamy, medium flour, the best results would be obtained. All these points are dealt with and emphasized in the following pages. In a subject like Flour Milling, where every detail and theory of the series of processes must be pointed by reference to, and in many cases sketches of, some machine employed on this particular work, it is very necessary to choose some standard make amongst the best types; but, on the other hand, it is quite impossible to mention every make upon the market. The number of excellent and high-class milling catalogues now issued by the leading milling engineers throughout the country can be obtained upon application, to fill the blanks unavoidably left in the present work. In conclusion, the author desires to most earnestly thank the following friends and makers who have so generously responded to a request for machine details for publication: Messrs. W. & T. Avery, Ltd.; Messrs. Briddon & Fowler, Ltd.; Messrs. E. Green & Son, Ltd.; Messrs. Galloways, Ltd.; Messrs. Gilbert, Gilkes & Co., Ltd.; Messrs. Thomas Hart; Messrs. Higginbottom & Co.; Messrs. G. Luther; Messrs. Mather & Platt, Ltd.; J. H. Reynolds, Esq., M.Sc. (late Principal of the Manchester School of Technology); Messrs. Thomas Robinson & Sons, Ltd.; Messrs. W. Rowlandson & Co., Ltd.; Messrs. Samuelson & Co., Ltd.; Messrs. John Staniar & Co., Ltd.; Messrs. Spencer & Co., Ltd.; Messrs. Henry Simon, Ltd.; Messrs. Frank Stacey & Co,; Messrs. E. R. & F. Turner, Ltd.; to *The Miller*, and its able editor; to J. M. Bardsley, Esq., of Manchester; to Messrs. Flatters, Milborne, and McKechnie, Ltd., of Manchester; and any others who have kindly rendered assistance and encouragement.

CHAPTER II

MILLING CONDITIONS IN ENGLAND, PAST AND PRESENT

THE English miller stands almost alone in his peculiarly difficult situation in the flour-milling industry. He has to deal with a motley collection of wheats drawn from all parts of the earth. As wheat grows from the tropics to the frozen zone, it will be understood what a wide range is covered. Wheat, like man, varies in strength, structure, and general characteristics with the climate, hence the great diversity of varieties. From the far North-Eastern Russia and Siberia we get a strong, thin, hard and dark grain. From far North-Western Canada we get a strong, fairly plump, hard and fine-coloured grain. From burning India, brittle, hard, dry wheat of fair strength and colour is obtained. From Australia comes a beautiful mellow, coloury wheat. From South America, thin, rather uncertain qualities of grain are shipped. From Persia and Egypt and like countries the wheats arrive dirty, ricey, and poor, as a rule. Some foreign wheats are, like our own, soft and weak, although yielding flour of a good white. So we ring the changes. Even if we could produce enough native grain we could not mill to pay, as our wheats do not possess all the qualities which go to make a good all-round flour. The problem for the modern miller to solve is, to mill a standard quality or qualities of flour, with profit, whilst mixing and blending wheats whose quantities, prices, and conditions are always varying; to play the dark, strong wheats against the weak wheats of good colour in such a way that the resulting flour shall combine the good qualities of both; to remove all extraneous matter from the dirty wheats (and use this to the best advantage); to bring all sorts and conditions of wheats to the same degree of hardness, toughness, and mellowness. To do all this thoroughly, the miller calls to his aid wind, water, steam, and dry heat, using each in turn to obtain the greatest effect. There is a limit to the

use of these, beyond which the grain deteriorates in strength and general characteristics. The modern milling equipment is a very complicated and adaptable organization. The serious drop in the quantities of native wheat, and the necessity of raising its general standard, have led to the formation of a Home-Grown Wheat Committee under the guidance of the National Association of British and Irish Millers. Experimental farms have been established in several counties, on which have been grown wheats from the sowings of the best foreign strong and coloury varieties. Owing to the effect of our climate and soil, the crops raised have deteriorated on the most desirable qualities. But the Committee hope in time to evolve a breed of wheat, acclimatized to local conditions, and yet retaining strength and bloom. They aim at hardness and improved quality of gluten, so that when ground alone the wheat shall produce a flour giving a dough of great elasticity, giving a loaf of relatively large size, of an even spongy texture, in place of the rather weak, close-textured loaf produced from existing English wheat flour. The quality and quantity of the straw is hoped to be improved. The demand for the strength and colour of flour must at present be met by using large percentages of the superior foreign wheats. The National Association of British and Irish Millers raise protests against the slackness and almost criminal carelessness of shippers from some of the foreign ports, which result in parcels of wheat reaching England in a state far below the sample forwarded. Badly graded and with abnormal admixtures of foreign seeds, refuse, and dust, it is high time that better and more conscientious methods were adopted. Forwarded to proper quarters and backed up by a large and influential body of millers, these protests have not been in vain, and the installation of great elevator and grading depôts at many foreign ports is largely the result of the determined agitation.

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CHAPTER III

HISTORY OF FLOUR MILLING

AMONGST the most advanced civilizations of the world, wheaten flour forms such an important part of the staple foods consumed that attention is being concentrated upon every step of the long process. The direct outcome of this has been that the last thirty years have seen more advancement than the previous thirty centuries. The old familiar millstones have practically ceased to exist as a wheat-grinding medium, and have been replaced by the grooved chilled iron rollers which form the backbone of the roller system.

The oldest history to hand relating to the grinding of wheat, or corn, dates back over 6000 years, in the early days of the Egyptian nation. The stones in use were named "hand-stones" or *querns*, and were simply two rough stones, the lower, which held the grains to be pulverized, had a slight depression in the top, the other one was simply a boulder, grasped to smash and crush the grains. It was simply a crude pestle and mortar. The *quern* was in use for 4000 years, as the sole means of grinding or reducing wheat. Even to this day it is used among the North American Indians, and in most Eastern countries.

Over 4000 years ago the millstones, a crude form of the ones we have supplanted by rolls, came into use. They were driven by slaves or cattle. For 4000 years the millstone was the only system in use. The only real progress made was in the sifting methods and the driving power. The Greeks first introduced a mechanically driven mill about 450–400 B.C. It was a watermill, and had a horizontal wheel, but no gearing. A hundred years later the Romans invented a vertical water-wheel with gearing to stones. About four hundred years later still they made the "ship-mill" which floated, and was worked by a flowing stream or tide. About 600 A.D. the windmill was invented. At first the arms revolved upon a tripod stand. Later a turret or tower

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took its place, and from it evolved the old familiar windmill. For hundreds of years the flour-milling industry has progressed very slowly, principally owing to the very severe laws and restrictions placed upon it. It is during the last thirty years that the real progress has been made. As the English nation grew in size, the quantity of wheat-growing land steadily diminished. Wheat had to be brought from abroad in enormous quantities, and their diverse natures and many impurities demanded a variety of treatment in cleaning, conditioning, and grinding. Steam was first used for driving mills about 1784, in London. Stones and bolting reels continued to be used right up to 1880, and even later. A new type of purifier was patented by a Mr. Westrup in 1854. In 1870 Mr. Childs, an American, introduced wheat cleaners into England, and Messrs. Wegman's porcelain rolls also appeared. Whitmore's purifier and centrifugal appeared between 1870–80. G. Bucholz patented an iron roller system in 1874, and fitted up a Liverpool mill. But the great revolution in Flour Milling came in 1881. During that year a great exhibition of roller milling was held in London, and millers attended in large numbers, anxious to see the system that was at work on the Continent and in America, and which enabled the Hungarians, the Germans, and the Americans to flood the English market with flour of such fineness and whiteness that the stone-made flour at home had no chance of good sales. Parties of millers also paid visits abroad under the guidance of Mr. Carter, and, being convinced of the hopelessness of fighting the roller system, wisely put the prejudice of years aside and set to work to install the new system into their mills.

Amongst the foremost of the milling engineers who helped the millers in the struggle were Messrs. Nagel & Kemp, Messrs. Henry Simon, Harrison Carter, J. W. Thropp, and Charles Hopkinson. Messrs. Carter were pioneers in many improvements, and Messrs. Simon introduced the finger-beaters in centrifugals, a clever and very effective improvement. A rotary scalper and a purifier by Messrs. Simon appeared in 1885. The numbers of foreign wheats which the English millers were forced to use now began to be a serious problem in the wheat screen room. The filth, which the careless and sometimes corrupt practices of the shippers caused to be amongst the wheat, created clouds of dust with which the primitive collectors were quite unable to deal. To meet the

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need, many inventions were put on the market, textile and cyclone dust collectors being the most effective. During the twentieth century roller milling has progressed in every department. Stone mills for flour making have practically ceased to exist. (*Grain handling* and *storage* have become a separate branch of the industry.) *Wheat-cleaning systems* have developed enormously, and are almost as complicated as the flour-making department itself. *Washing*, *steaming*, and *conditioning* are now regarded as a necessity for profitable milling. The main note has been *mechanical handling* wherever possible, so as to make milling almost entirely automatic.

To sum up: The history of Flour Milling can be expressed in periods:—

1.	The hand-stone or quern	4000 B.C. to
2.	The slave and cattle driven millstones	2000 B.C. to
3.	The Greek single water-wheel millstones . . .	450 B.C. to
4.	The Roman geared water-wheel with several stones	350 B.C. to
5.	The windmills	600 A.D. to
6.	The steam-driven mills	1784 A.D. to
7.	The roller-mill system and cleaning systems . .	1881 A.D. to
8.	The present-day perfection of the roller-mill system and development of grain handling, storage, cleaning, and conditioning, reduction and the artificial bleaching and conditioning of flour	1914 A.D.

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CHAPTER IV

THE WHEAT BERRY

History of Wheat.—Wheat has been chosen by man from amongst the many cereals grown as his staple food because it contains a greater percentage of nourishment than any other cereal.

Wheat (*Triticum vulgare*) belongs to the order "Graminæ." It is an annual (of the group of farinaceous grasses called cereals—from Cerea, the Roman Goddess of Corn). It is divided into two classes, *Winter* (or Autumn), *Spring* (or Summer). It is grown under three colours, White, Red, and Yellow. The *White* standing for colour, yield, and whiteness; the *Red* for strength and bloom; the *Yellow* for harshness and hard to flinty natures; they are also in order of quantities grown. The origin of wheat is lost in obscurity. Wheat will grow under extremes of heat and cold, but not to such perfection as in the temperate zones. It will grow in a wide range of soil, but attains perfection in a deep loamy soil, rich in converted vegetable and animal deposits. The worst soil for the growth of wheat is that which is composed of layers of mud over sand, such as obtains on the banks and the delta of the Nile—Egyptian wheat being notoriously bad. Broadly, soils and climates most suitable for the growth of rice are most unsuitable for the growth of wheat. Therefore deep rich soil, moderate rainfall, snowy and severe winters, and bright genial summers are most favourable for the growth of perfect, strong, and good yielding wheat.

The Germination of a Grain of Wheat.—In every sound grain of wheat there are enclosed within the shell or bran, first, the germ or living seed, next a small quantity of soluble gluten, then a large proportion of insoluble gluten, and then the starch, by far the greatest proportion of the whole grain, also insoluble by water. These constituents will change and alter with age, but to no great extent ***in the dry*** (except

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after the lapse of thousands of years as in the case of " dead " wheat found in Egyptian mummies). Directly moisture (to the extent of 20 per cent. of its bulk) and heat (from 40° to 100° F.) come into contact with the berry, a change takes place. The germ is first affected, and in turn attacks and acts upon the soluble gluten. This renders the insoluble gluten soluble. The latter increases in size, and, attacking the starch, renders it also soluble and converts it into sugar upon which the growing plant feeds. During these changes the little germ has begun to send up a tiny spike of life, the plumula, or blade, and to send down a rootlet, or radicle. The germ could do this by itself, but must have food to back up its growing progeny. The subsequent transformations of gluten and starch are solely to provide this food. By the time the food-bag is exhausted, and the grain but a hollow husk, the radicle has taken a firm hold of the ground and is obtaining nourishment from it, and the plumula has penetrated into the open air and sunlight.

FIG. 1.—MICRO-PHOTO SECTION THROUGH WHEAT GERM.

Fig. 1 is a micro-photo of the section through a wheat germ. As a scientific analysis, it should be closely studied. The photo was taken by Messrs. Flatters, Milborne, and McKechnie, of Longsight, Manchester, who make a speciality of this class of photo investigation. (The author desires to express his thanks for their kindness in readily supplying the photo.) To carefully examine the reproduction. At the bottom right-hand corner will be seen the several layers of the bran coats or wheat skins. Next comes a dark strong line, probably caused by the glutenous inner lining. Next, the white space, darkening and becoming

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clearly detailed at the top of the section, is really the flour-bag or endosperm. The minute cells, quite invisible to the naked eye in the actual grain, are here seen clearly. Then, well-defined in outline and in detail, we have the dark mass (yellow in the actual thing) of the germ. It has just started into life, and the peculiar working action of the agitated germ can be plainly traced. It is attacking the soluble gluten cells at its borders. The black and white plumula section, with its tiny shoot just showing, is connected to and in communication with the radicle, by means of the "tide" of molecules circulating to and fro between them. The radicle, seen at the extreme bottom left-hand corner, is all concentrating upon its tiny beginnings of a rootlet in a most unmistakable way. When it is realized that the whole germ is only $\frac{1}{10}$ of the grain, the actual magnification of the original berry can be more fully realized.

The building up of the grain takes place in the following manner: the *Epidermis*, the outer covering of extreme lightness, is followed in succession by the *Epicarp*, formed of long and pointed vessels in double rows; the *Endocarp*, composed of light open regular cells, round and almost of the same constituents as straw; the Testa, of close texture with minute cells, containing two colouring pigments, one pale yellow, and one orange-yellow. The soil, and the chemicals drawn from it, determine to a certain extent which shall predominate, and hence spring the varieties of red, yellow, or white wheats. The *Embryonic Membrane* is an expansion of the germ or embryo, and is composed of roughly cubic cells, diminishing in size towards the germ, and surrounded by cerealine. Last comes the *Endosperm*, or flour bag, consisting of particles of starch and gluten, which all the other layers are designed to protect. The outer layers of the endosperm consist of square cells, composed of cellular tissue, phosphate of chalk, insoluble cerealine, and phosphoric bodies of a fatty nature. These vary in thickness with the ripeness of the wheat and in strength also. Inside these cells again is a network of gluten, whose ramifications extend right into the heart of the berry. The outer layers of endosperm are richer in gluten than the inner ones—being nearer the influence of sunlight and warmth. The *germ* is a mass of cells full of fatty bodies.

An average crop of 100 bushels of wheat will draw from the soil to its berries, approximately, 13 lbs. magnesia, 44 lbs.

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phosphoric acid, 4 lbs. soda, 2 lbs. lime, 3 lbs. silica, 33 lbs. potash, and a trace of sulphur and chlorine. The amount of nitrogen necessary to produce this crop would be approximately 100 lbs. in the ripe grain.

We will now proceed to analyze a grain of wheat. A reference to Fig. 2 will show how well protected the flour cells are from outside influence, and how impossible it would be to extract all the flour, without powdering or breaking up the bran coats.

The wheat berry is built up in the following proportions :—

Epidermis . .	0·5 p.c.
Epicarp . . .	1·0 ,,
Endocarp . .	1·5 ,,
Testa	2·0 ,,
Embryo (or germ)	2·0 ,,
Embryonic membrane . . .	3·0 ,,
Endosperm . .	90·0 ,,
Total contents	100·0 ,,

INSOLUBLE NITROGENOUS SUBSTANCES. — Relative ratios: Wheat, 23. Barley 14. Oats 11. Maize 7. Rice 3.

CHIEF ELEMENTS OF GRAIN.

Carbon . .	Greater part.
Oxygen . .	Existing in combined form as moisture.
Hydrogen .	
Potassium .	Traces only, in combination, materials in soil dissolved and drawn in with the moisture.
Sodium . .	
Silicon . .	
Iron . . .	
Magnesium .	
Sulphur . .	
Phosphorus .	
Calcium . .	
Nitrogen . .	Found in gluten.

The following interesting figures are from "The Chemistry of Bread-making," by James Grant, M.Sc.Tech., F.I.C., F.C.S., and relate to the composition of various wheats.

WHEATS.

Constituents.	English.	English.	Russian.	Canadian.	Argentina.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	10·74	13·56	12·77	13·97	12·29
Proteins . . .	11·98	12·42	17·26	12·48	13·12
Fats	1·29	1·73	1·59	1·57	1·43
Mineral salts . .	1·37	1·84	1·71	1·73	1·58
Cellulose . . .	2·26	2·38	2·13	2·88	2·73
Starch, Sugars, Dextrins, Gums	72·15	67·69	64·38	67·17	68·60
Undetermined .	0·21	0·37	0·16	0·20	0·24

Although strength must be associated with the total percentage of gluten or nitrogen in a flour, yet it is the *physical*

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properties of gluten, *i.e.* its qualities, which determine its strength in bread-making.

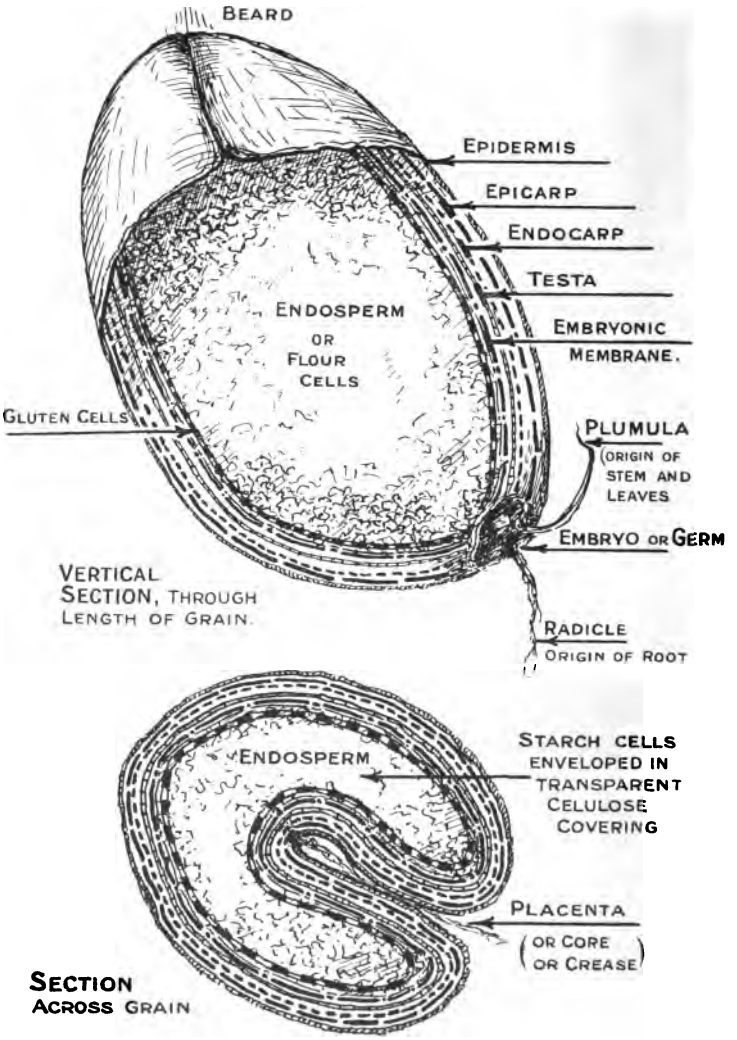

FIG. 2.—SECTION THROUGH GRAIN. NATURAL CONSTITUENTS.

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Gluten lies near the embyro membrane and decreases in proportion towards the centre of the grain. The centre cells of endosperm contain 8 per cent. gluten (and are therefore nearly pure starch), and the extreme outer cells contain 13 per cent. These latter, being nearer the influence of the sun and warmth, in the ear of wheat, are riper.

Gluten is composed of two parts: gliaden, and glutenin. A grain of wheat contains six times more starch, or heat-producing substance, than gluten, or flesh-forming matter.

The chemical constituents of the wheat berry are usually divided into two parts—the nitrogeneous (gluten, albumen, cerealine), and the non-nitrogeneous or carbohydrates (starch,

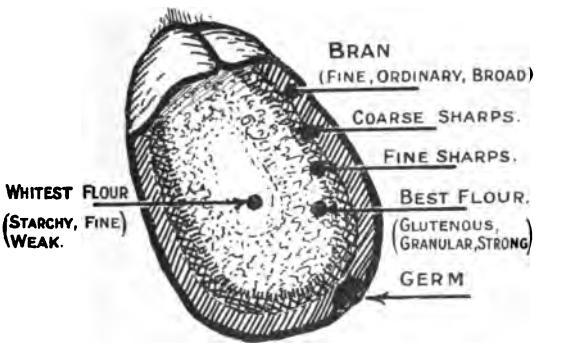

FIG. 3.—SECTION THROUGH GRAIN. COMMERCIAL PRODUCTS.

vegetable fibre, germ and sugar). These two are organic substances. The inorganic parts are ashes, salts, and water.

A useful and instructive way to study the wheat berry is in the light of terms of the commercial products into which modern milling methods divide it. Fig. 3 indicates the main classifications. The amounts given are those obtained in ordinary practice, the unavoidable shattering and crushing of the particles on the dividing line of each section cause a certain amount of intermingling of each adjoining set of cells. Although the average grain of wheat contains 90 per cent. of endosperm or flour bag, only approximately 70–71 per cent. of undefiled or pure stock flour is obtainable; in the old days of soft native wheats, and the rough treatment upon mill-stones, this frequently went down to 64–65 per cent. The meeting ground of the flour-particles and the encasing bran coats is the commercial product known as "sharps"—the

hopeless mixture of the two finely reduced products. Keeping the diagram before him, the student will be helped to realize just the reasons governing the long and elaborate processes following, from the moment of wheat intake to the moment of stocks being sacked off. He will see why the toughening of brittle wheat skins, and the hardening of soft skins, is so strenuously followed up in the conditioning process. Because, as the diagram points out, the strongest and best flour particles (*i.e.* the most glutenous) are situated immediately beneath the wheat skins, and from their very tenacious nature these will be the last to leave the bran. It is most desirable from all points of view, flour strength, quality, and profit, etc., that these should be efficiently and cleanly removed without breaking up the bran, and thereby contaminating them. The miller seeks to render the skins, of all the widely-varying wheat natures, fit to stand this treatment of " cleaning " on the last break rolls, before being drafted, fully classed, out of the system, as bran. The centre flour cells are weakest, finest, and whitest. The much debated germ will be noticed. It is quite a small feature of the commercial products of the grain, and receives but scanty attention from the majority of millers. The 80 per cent. " standard " flour, so prominently before the public at one time, can be obtained by allowing 10 per cent. of the outlying border of fine offal (fine sharps) to drift in with the flour, and reduce the whole mixture to a " dirty white " or pale brown tint. By allowing the germ and all but the outer, coarser layers of broad bran to mix in with the flour, we get the sweet-tasting brown meal producing the brown bread so much in favour amongst sections of the community. Last of all we get the whole grain reduced to a meal and termed " whole meal." From these considerations it will be seen how complex must be the series of processes necessary to obtain the 70 per cent. of flour and its attendant stocks from the wonderful little grain, in a pure state, whilst reducing it to hundreds of thousands of particles by enormous pressures and searching and repeated sifting, yet without rupturing the finest cells and damaging the strength, knowing with precision the results to be obtained, and maintaining these percentages in an almost unvarying degree for weeks at a time, with changing mixtures and working conditions.

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CHAPTER V

THE WORLD'S WHEATS AND WHEAT LANDS

WHILE it is not possible to devote space for an exhaustive survey of all countries in respect to all the forces governing the wheat output, except to briefly deal with each principal wheat-growing country, as to soils, climates, conditions of growing, harvesting, storing, grading, and dispatch abroad, these factors have a bearing upon our own welfare.

There are three methods of defining the quality of foreign grain, and they are thus described in contracts of the London Corn Trade Association:—

" (1) Of fair average quality of the season's shipments at time and place of shipment (termed ' F.A.Q.' terms)."

" (2) At time and place of shipment about as per sealed samples."

" (3) Official certificate of inspection to be final as to quality."

This last method is also used for grain imported from the Atlantic ports of the United States.

The United States have in many cases impoverished the soil, damaging its yielding properties. In such a huge country there are many varieties of soils, but in the main it is of glacial origin, dark coloured, rich in lime and organic matter. Clay and silt loams are strongly in evidence, especially in the Upper Mississippi Valley. Away West in the Colorado district, the ground becomes harder, being silicious and stony. It is not so suitable for the growth of strong wheats. The hardness imparted is of the flinty somewhat treacherous nature, which one might expect from growths in such soils. The Pacific Coast and California have a stony and sandy soil, and a dry, warm climate, and weak and brittle wheats. In the Minnesota and Dakota districts, where some of the most valuable strong, hard spring wheats are grown, the winters are cold with hard frosts and rather heavy snowfalls. The rainfall in summer is moderate, but the harvest season is generally

sunny and brisk. These great plains are at a level of about 800 feet above the sea. The Mississippi district lies at about 350 feet above sea-level, and the climate being somewhat damper and milder, a softer wheat is produced, not quite so strong. This is the winter wheat district. Their wheats may be placed under two headings. (1) Hard Spring, and (2) Winter (soft). The spring wheats are usually sown in April, and the winter wheat in September. The harvesting seasons range from May to September. The Hard Spring wheats, red-grained and rich in gluten, are grown in the Northern States. The "Hard" Winter wheats, red-grained and with good average gluten content, are grown in the Middle States. The semi-hard winter wheats are grown in the North Central States. The soft winter wheats, colour from amber to white, are grown in the Middle Atlantic and New England States. The white wheats, soft and starchy, are grown on the Pacific Coast, whilst the hard flinty Durum wheats are grown in the "dry-farming" and irrigated Rocky Mountain and Basin States.

The Club, or square-head wheats (*Triticum compactum*), white, with occasional red varieties, are short, rather small grain, of good yielding properties, and with chaff of a tenacious nature, can be either spring or winter and can be harvested early, not being liable to shed or damage.

Emmer and Spelt wheats are also grown in small quantities; the former stands water shortage well. Both are stock and forage varieties mainly. The yield of wheat per acre varies considerably with the seasons and with the types of wheat grown. Twenty-five and even more bushels per acre have been reaped, but the average for winter, 1906–10, was approximately 15·5, and for spring, 1906–10, 13·5 bushels per acre. The system of harvesting in the States is usually good, and automatic harvesters and threshers of great size, drawn by teams of horses, are employed. Wheat storage is effected either (1) at farms; (2) at local markets; (3) at primary markets; (4) at the seaboard. Official grading takes place mainly at the last two. The grain elevators at the lakes and seaboard are of great size and are fitted with very complete handling, grading, and cleaning plants. The great waterways, the canals and the lakes, the four-transcontinental railways, and others in the making, have in a greater degree an important bearing upon the transportation of wheat. The storage elevators *en route* on these latter range from 15,000

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to 50,000 bushels capacity. The shipping and receiving of wheat in the United States are in the hands of a few powerful combines. The cost of storage at the main and lake ports varies from 0·5 cent per bushel for first 15 days, to 0·75 cent per first 10 days at Duluth and Chicago respectively.

Grain inspection and grading were first systematically adopted in the United States. Selling on sample only was found to be a most unsatisfactory method. Boards of Trade and trade organizations established a system of contract grades of wheat. Car-loads arriving at an elevator for storage are inspected by special samplers and inspectors, who determine the grade of grain, judging on colour, soundness, plumpness, weight per bushel, and percentage of screenings.

The commercial grades of wheat recognized at Chicago are—[1]

White Winter Wheat, Nos. 1, 2, 3, and 4.
Long Red Winter Wheat, Nos. 1 and 2.
Red Winter Wheat, Nos. 1, 2, 3, and 4.
Hard Winter Wheat, Nos. 1, 2, 3, and 4.
Colorado Wheat, Nos. 1, 2, and 3.
Northern Spring Wheat, Nos. 1 and 2.
Spring Wheat, Nos. 1, 2, 3, and 4.
White Spring Wheat, Nos. 1, 2, 3, and 4.

Wheat of poor quality or condition is classed "rejected" or "no grade." An idea of the rules governing the grading of wheat may be gained from the following rules on the Minneapolis market.

"Northern Spring Wheat.

"No. 1 Hard Spring Wheat shall be sound, bright, sweet, clean, and consist of over 50 per cent. of hard Scotch Fife and weigh not less than 58 lbs. to the measured bushel.

"No. 1 Northern Spring Wheat shall be sound, sweet, and clean, may consist of the hard and soft varieties of spring wheat, but must contain a larger proportion of the hard varieties and weigh not less than 57 lbs. to the measured bushel.

"No. 2 Northern Spring Wheat shall be spring wheat, not clean enough or sound enough for No. 1, but of good milling quality, and must not weigh less than 56 lbs. to the measured bushel.

"No. 3 Northern Spring Wheat shall be composed of

[1] From "Wheat-growing in Canada, U.S.A., and Argentina," by W. P. Rutter.

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inferior shrunken spring wheat, and weigh not less than 54 lbs. to the measured bushel.

"No. 4 Northern Spring Wheat shall include all inferior spring wheat that is badly shrunken or damaged and weigh not less than 49 lbs. to the measured bushel.

"Rejected Spring Wheat shall include all varieties of spring wheat sprouted, badly bleached, or for any other cause unfit for No. 4."

The U.S.A. winter wheats arrive in Europe in August; the spring wheats in October.

The main wheat ports are divided between the two coasts, the Atlantic and the Pacific coasts respectively. On the Atlantic coast are Portland, Boston, New York, Newport, News, Philadelphia, Wilmington, Baltimore, Norfolk, Charlestown, Port Royal, Pensacola, Mobile, New Orleans, Galveston.

On the Pacific coast are Astoria, Portland, Tacoma, San Francisco, Monterey, Wilmington, San Diego.

Main U.S.A. wheats available for English markets are Duluth, Northern Spring, Red Winter, Kansas Winter, Western Winter, Michigan, Durum, Oregon, Walla, Blue Stem, Californian Goose Wheat.

Canada is still regarded as the "land of promise." North-West Canada is still largely awaiting the wheat farmer. The soil is rich in mineral and animal and vegetable deposits, and is generally well-watered. The climate of the north-west is, in most respects, a suitable one for the full development of the strong valuable kinds of wheat. The spring is short, after long winters with deep snow and often extreme cold. The harvest season is mostly dry and sunny. Both Canada and the Northern States of the U.S.A. feel the need of a protecting range of mountains guarding from the sudden and disastrous blasts of cold at harvest time from the Arctic regions. One of the worst features of the best Canadian wheats is the frosted samples, which go to swell the lower grades. The hard, strong Spring wheats are grown in Manitoba, most of Saskatchewan and Alberta, the latter having still a large quantity of virgin soil; North-West Canada generally is suitable for this class of wheat. Strong, hard winter wheat is grown in South Alberta. Soft white and starchy wheats are grown in British Columbia. Western Ontario produces soft winter wheats mainly, whilst soft Spring wheats grow in Quebec and the Maritime Provinces. Small quantities of Durum come from South-West Saskatchewan. Winter wheats are sown

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in August and September and harvested the following July and August. Spring wheats are sown in April and harvested in August. Red Fife is the most favoured in the Dominion. It is remarkable for its powers of adapting itself to wide variations in soils and in climates and is very productive. The wheat yields per acre vary from 13 to 25 bushels. Winter wheats lead. Harvesting operations follow much on the lines of the United States, the combined harvester-thresher being largely used. Wheat storage again largely resembles that of the States. Grain elevators, large and small, follow up the rail developments and the opening up of new districts. Her fine system of waterways and the five great railways, including the Canadian Pacific—the "C.P.R."—have largely helped to develop Canada as a grain-growing country. The elevators on the lakes, and on many of the grain routes and centres, are rapidly growing in size and handling facilities.

The usual method of unloading cars is to scoop the grain out automatically, tip it into a pit through a grating, deliver to a band conveyor, for weighing, cleaning, and inspection, and thence to elevator for final delivery to car or vessel. Urged on by British millers and grain merchants and shippers, and desiring themselves to supply satisfactory grades for the development of the staple industry, Canada now supplies some of the world's most uniform grades. Canadian Spring wheats arrive in Europe in November.

The main wheat ports are: on the Atlantic—St. John's, Halifax, Quebec, and Montreal; on the Pacific—Seattle and Vancouver.

The main Canadian wheats on English markets are: Hard Manitoba, Northern Manitoba (these include Hard Fife, and new wheats such as Alberta), Soft Red and Soft White Canadian.

In **South America**, the most important wheat-growing country is the Argentina. The wheat-growing districts are mostly on the level pampas. The soil, most of which is rich, in some places is of heavy black alluvial deposit, upon hard clay, and in others of volcanic origin composed of fine, light siliceous soils containing a considerable portion of vegetable earth. The climate is open enough to enable the farmer to work his land almost all the year round.

Locusts are also a peculiar trouble of South American farmers. The Argentine wheat regions can be divided into three main districts. The hard Durum wheats are grown in

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the north, including mainly the northern sections of Entre Rios and Santa Fé.

The semi-soft wheats are grown in the centre, in the provinces of Santa Fé, Buenos Ayres, Entre Rios, and Cordoba.

The semi-hard wheats are grown in Rio Negro, Pampa, and Chubut territories. The main bulk of the wheat exported is of the semi-soft varieties, such as Barletta, Saldome, Hungarian, Tusela, etc. The latest crop is reckoned at a yield of 11·3 bushels per acre. Argentina seeding begins in May and ends in August; harvest in December, and ships for Europe at the end of January, between the arrivals from North America and South Asia. The harvesting and storage of wheat are often primitive, and much might be done to improve the methods employed.

One very valuable feature of the country is the magnificent waterways which so largely help the transport of grain. The Parana and the Uruguay, which, united, form the La Plata, are fed by large numbers of tributaries, all assisting to open out the country. Railways are also progressing and further linking up the different districts. The grading of wheats is by no means satisfactory, Plate wheats often being of uncertain quality and not up to sample. Large elevators have been and are being erected at the main ports. These latter are: on the Atlantic—Bahia, Blanca, Monte Video, Buenos Ayres, Colastine, Santa Fé, Parana, Diamante, Puerto, Gomez, San Lorenzo, Cerano, Rosario, Villa Constitucion, San Nicolas, San Pedro, Zarate, Campana, Eusenada (La Plata), Rio Janeiro; on the Pacific — Valparaiso, Concepcion, Talcahuano.

The main wheats shipped to England are Chilian, Plate (Bahia Plate, Rosario, or Rosa Fé), Bahia-Blanca, Candeal, and Saldome, Choice Plate (Barletta), Uruguay.

Australia has a good reputation for a valuable class of wheat. The majority of the wheat lands lie at low altitudes, and are often of a light to sandy nature. Victoria and New South Wales are the great wheat-growing districts. Snow or cold of any degree is practically unknown, and although heavy rains, almost in the form of a deluge, are experienced on occasions, in the main the climate is dry, hot, and intense. The conditions are not favourable to the development of strong, hard wheats, but Australian grain has valuable qualities in the form of high flour yield, splendid bloom and colour almost indispensable for blending. The sowing takes

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place mostly in July and August, and the harvests from December to January.

The average yields in bushels per acre vary from 7 to 22. The storage of wheat in bulk in elevators at main ports is not so fully developed as one would imagine. In 1908 the Australian Minister of Customs instituted a standard bag of 200 lbs., and this has been widely adopted for wheat storage. The generally uniform quality and cleanliness of Australian wheats simplifies the grading question.

Australian ports are mainly Rockhampton, Maryborough, Brisbane (Queensland), Port Macquarie, Port Hunter, Sydney (N.S. Wales), and Melbourne, Geelong (Victoria), Hobart (Tasmania), Adelaide (S. Australia), Perth (W. Australia).

New Zealand has a soil and climate not unlike England, and, like us, has not found wheat-growing very remunerative. The grain is large, of fine colour, but soft and weak. Practically being a second-rate type of English growth, has almost ceased exporting.

New Zealand main ports are Napier, Wellington, Christchurch, and Bluff Harbour.

Main wheats arriving at English markets are "Victorian," "West Australian," "New Zealand."

Europe has probably the greatest diversity of soils and climates of all wheat-growing continents. Russia, in spite of almost hopeless drawbacks in the shape of slovenly methods of farming, badly framed laws relating to grain, corrupt "cleaning," grading, and shipping methods, is still one of the main grain arteries of the world. The rich soil and the climate are, like Canada, capable of producing the strongest types of wheat. The soil of Russia, especially that of the South, is often termed the black earth zone, and is composed of rich vegetable deposits, often very deep and capable of being used for years as wheat-producing land, if well-tilled and ploughed. It is well-watered and has all the makings of a great wheat land. The climate is similar to the fellow wheat lands in the West (the North-West of Canada and America). Extreme cold in winter, with deep snows and ice-bound rivers, is the condition of Russia and Siberia for many months. The summer is short and brilliant, and the wheat crops must be grown and harvested by August. The two main types of wheat exported are the Azima (or winter wheat), and the Ghirka (or spring wheat), both types being of a strong red kind. South Russian wheats have lately been

available in large quantities, but the quality has often been poor, and the grains thin and of indifferent yield. Wheat storage is in a bad state generally. The grain is either heaped up casually, or stood in coarse bags. The first public elevator was erected at Eletz by the local government authorities in 1888, and those built since have been by the Railways or the Government.

Importers of Russian wheat usually buy " on sample," with a liberal discount as to cleanliness and percentage of screenings. Soon after the harvest, samples of the crop are forwarded to the European markets, and standards are made for the year on the lines of " fair average quality." Russia suffers from want of seaports. Samples fair—parcels full of foreign seeds and earth, which had absolutely been shovelled in from the quayside during shipment—is the usual order of things. The clean and satisfactory parcel of Russian wheat is the exception rather than the rule.

The main wheat ports are: on the White Sea—Archangel: on the Baltic—St. Petersburg, Cronstadt, Reval, Riga, Pernau, Windau, Liban; on the Sea of Azof—Taganrog, Rostov, Azov, Temrink, Marianopol, Yeisk, Berdianski, Ghenighesk; on the Black Sea—Theodosia, Kherson, Sebastopol, Eupatoria, Nicopol, Nicolaieff, Odessa, Anapa, Yenikale, Novorossisk, Poti, Batoum.

The main wheats reaching English markets are Azima, Ghirka, Taganrog, Kubanka, Ulka, occasionally Saxonska, Polish.

The terms " North " and " South " Russian are also frequently used now for grades of this wheat.

Austro-Hungary is a country with a rich soil, full of animal and vegetable deposits. Its tablelands compare favourably with the best American wheat prairies, and are capable of producing fine strong wheats. The climate is that of the average Northern European country, with severe winters and fairly hot summers, and a rather heavy rainfall. The main classes of wheat grown are strong reds, with gluten of a sound elastic quality. The Danubian provinces, including Bulgaria, Roumania, Moldavia, etc., usually supply large quantities of a steadily improving quality, although the peculiar yellow tint still clings to flour made entirely from these Danubian reds. Their strength is not up to the quality of the Russian, but their usual cheapness for wheats of their strength and cleanliness is steadily bringing them into favour. The

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Government have established a regulation that wheats exported must weigh at least 60·75 lbs. per bushel.

Turkey, especially from its wheat lands along the Danube, has qualities of a fair average of grain, and exports useful quantities in a good season.

Germany, with a soil in the main similar to England, produces a wheat of moderate strength, large-grained, and thick-skinned—although samples come to hand occasionally which show signs of strength. Cleanliness and a small percentage of screenings are a feature of these wheats.

The rest of the countries of Europe need not be dealt with in detail here, because we do not deal with their wheats. They are mostly in the same position as ourselves—unable to support their populations upon the home crops.

Turkey-in-Europe.—On the Danube—Galatz, Sulina, Tultcha, Braila; on the Black Sea—Kustenjeh, Baltchik, Varna, Burgas, Samsoon, Sinope, Constantinople, Gallipoli; on the Sea of Marmora—Scutari; Greek Archipelago—Salonica, Dede, Agatch.

Austria.—On the Adriatic Sea—Trieste, Fiume.

Germany.—On the Baltic Sea—Konigsberg, Danzig, Rostock; on the North Sea—Hamburg.

The wheats from Turkey are named, mainly, Danubian and Salonica; from Germany: Dantzic, Konigsberg, and Rostock; remaining countries: Hungarian, Samsoon, Persian, Moldavian.

Asia.—Practically only three countries in Asia directly affect us—India, Turkey-in-Asia, and Persia. India furnishes us with wheat in large quantities, and is one of our greatest "make-weight" and bulking sources of wheat supply. Most port millers look to Indian grain to provide the safe filling material between expensive strong and expensive coloury wheats. The danger in using too much of these wheats lies in the fact that they are very dry, brittle, and of a somewhat beany or strong flavour. The soil of the cereal-growing lands of India is mostly of a sandy nature overlaid with fine mud or silt from the yearly overflow of the large rivers, such as, for instance, the Ganges. Such districts furnish the better class of grain, of a fine soft texture and good quality. The wide tracts of country clear of the river margins are exposed to the intense and burning days of this land, and produce as a natural result the coarse, brittle, and harsher wheats. The excessive dryness of the air in these exposed districts is almost without

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parallel in the world, consequently the wheat produced there is the driest and gives the most trouble in the washing and conditioning plant. A good deal of arid land in India is being developed and made into useful wheat-producing soil by efficient irrigation. The results following upon the reclaiming of a large tract exceeded anticipations, and great developments will probably follow on the same lines.

The general conditions governing the producing, handling, storage, and shipments of wheat from India have no exact parallel in any other country. Great fluctuations in the amounts grown, from climatic or other reasons, occur at intervals. Indian wheats are divided in the following main groups: *Calcutta* (No. 1 and 2, Hard and Soft Red); *Kurrachee* (Red, White, and Choice White); *Bombay* (No. 1 Club, Red Club, Soft Red, Hard Red, and Hard White); *Delhi* (Soft Red and Soft White); and a few others of small importance. These are recognized by the English Corn Trade Associations, and are at least a weapon in their hands against the fraudulent practices of some Indian shippers. The yield per acre fluctuates considerably. The storage of grain has always been a matter of severe criticism by the progressive millers and grain merchants of Great Britain and India. The wheat is stored in underground warehouses, silos, and other receptacles. Filth and foreign matters of all kinds are mixed with it. It is often threshed by the methods in vogue centuries ago, trodden out on the bare earth by oxen. Dispatched by oxen waggons to the ports, its progress through the villages is a source of gratification to the inhabitants who have dust and rubbish to get rid of. By the time it reaches the depôt and is transferred to the ports and the ships, another liberal contribution being added from the spare earth of the quayside, plus any old papers, maize cobs, and other rubbish, it has swollen to quite large proportions. The great port of Karachi is the most notorious for this disgraceful state of affairs, and so well is this recognized on the Exchanges of London and Liverpool that Kurrachee wheat is bought only on the "clean" sample. This means that, from every large parcel or cargo of this wheat arriving in England, the Traders Associations reserve a quantity for testing. After a preliminary cleaning, the percentage of absolute rubbish is reported. The price at which that wheat was quoted is lowered to meet this loss of "wheat" per quarter. The railway transport facilities of India are fairly good, the bulk of the crop being rushed direct to the ports. The heavy

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rains, beginning at the end of June, usually catch the indifferently stored grain, damp it, and start mildew, heating and moulding of the heaps. Rats and human thieves take their toll also, and weevils cause almost ruinous damage on occasions. Up-to-date storage would obviate a great deal of this. By far the greater part of the wheat export of India comes to England. The deliveries of wheat from India have been the dirtiest of all parcels received, Russia not excepted. Over 20 per cent. of refuse has been extracted from Kurrachee consignments before they were fit to mill! The shipments from India are termed the "ante-monsoon" and the "post monsoon," the former dating from the new harvest and finishing about the end of June, and the latter from the start of July to the end of the crop year. The ante-monsoon shipments are cleanest.

The following are the chief Indian grain ports: Calcutta, Madras, Bombay, Kurrachee (or Karachi), Burmah, Bassein, Rangoon.

Main wheats shipped from India for English markets are Bombay, Calcutta, Delhi, Kurrachee.

Turkey-in-Asia produces a hard to flinty dry grain, following on a harsh, dry and rather sandy soil, and a hot climate and low rainfall. There has been practically no development of late years. The actual amount grown is only known approximately, and but small quantities reach this country.

Persia has also failed somewhat of late years as a cereal country. The poor soil and indifferent cultivation and the dry climate are all against any really reliable types of wheat. The shipments are usually of the common hard wheats, dirty and of poor value and low price.

Asiatic Grain ports.—Asia Minor: Mediterranean Sea—Smyrna, Messina, Gaza. Persia: Bushire. Turkey-in-Asia: Busrah, Arabia, Aden (Red Sea), Syria, Beyrout (Mediterranean Sea).

Africa hardly figures as a wheat-producing continent, as far as our markets are concerned. The largest grain-growing countries are Algeria and Egypt, and neither of these figures seriously in the English markets. Egypt produces wheat exactly in accordance with the soil and climate. The soil is nothing but desert sand overlaid by rich muddy deposits from every periodical overflow of the Nile. Irrigation at Assuan, especially, has done much to increase the wheat and crop-bearing soil, by reserving the water carefully behind the

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huge dam, and by letting it overflow the country below at certain periods, the country has been made very productive. The wide stretches of the Delta are the best example of surface crop soil in the world. The roots of the wheat plants pierce the layers of mud and find nothing but sand beneath. The grain is weak, dark, and of all-round poor quality. It is ricey and usually very dirty. Its best use is in producing good sizing flour. The port is Alexandria. Wheat termed "Egyptian" only.

Other African ports are Algiers, Tripoli, Benghazi (Mediterranean Sea); and on the Atlantic—Tangier, Mogador, and Saffi.

In order to make the list of the world's wheat ports complete, the following list must be added to those already given under the headings of the countries specially of moment to us as grain exporting:—

Europe.—France: Marseilles, Calais, Havre, Nantes, Bordeaux. Denmark: Copenhagen (Baltic). Holland: Antwerp, Rotterdam (German Ocean).

From all the particulars it will be seen that the Old World still produces great quantities of grain, and with careful treatment and land development the limit of production is still far ahead, especially in Russia and Siberia. England will probably steadily regain some of the lost ground. The New World, especially Canada and the Argentine, has vast possibilities of wheat-land extension. The United States will probably steadily decrease its wheat export, requiring it for home use. Irrigation will play an important part in the development of arid and semi-arid lands, it having been proved very beneficial in India and Egypt for reclamation. Canada, U.S.A., parts of South America, North Africa, and India will benefit most. Storage facilities in most countries are largely increasing, and are on improving lines. International conferences, criticisms, and complaints are resulting in better breeding, grading, cleaning, and storage. Electricity in the form of cables " and wireless " all tend to link up wheat and crop exchange news throughout the world. Fast steamers, rapidly growing railway, canal, and lake systems enable wheat to be forwarded with rapidity and precision. Wheat afloat is under market control, and can be bought and sold *en route*. The state of wheat supplies, prices, and markets has such a direct effect upon the price of almost every commodity that " grain is money." England has ceased to be an important wheat-growing country, mainly because of the

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great drop in prices in the last few decades. The price of wheat in 1800 was 119*s.* per qtr.; in 1817, 96*s.*; in 1840, 67*s.*; in 1867, 64*s.*; in 1877, 57*s.*; in 1882, 46*s.*; in 1891, 37*s.*; in 1898, 34*s.* In 1899 native wheat sold at 25*s.* 6*d.* per qtr. mainly because the world's crop was an abnormally large one. Since then it has recovered somewhat, selling in 1905 at 29*s.* 6*d.*; in 1908, at 32*s.*; in 1910, at 38*s.* to 40*s.*; and 1912, at 38*s.* to 40*s.* also. In 1856 approximately 4,200,000 acres of land were wheat-producing in England. In 1882, 3,000,000; in 1907, 1,600,000; and in 1909, 1,500,000. The crops produced in 1882 and 1907 were approximately 9,300,000 qtrs. and 6,600,000 qtrs. respectively. In 1882 the amount of wheat consumed per head of the population = 355 lbs., of which 117 lbs. were grown, and 238 lbs. imported. In 1907 the total = 352 lbs., of which 68 lbs. were grown, and 284 lbs. imported. Our dependence upon foreign countries is to be deplored, and in time of naval wars this wheat-supply question would be the absorbing topic (when too late), and would have the final ruling word in the result. Long and vainly has the gospel of great port storage facilities, Government controlled, been preached.

Strong wheats being confined to a few countries are always in demand. North-West States of America, North-West Canada, South Russia, and Austro-Hungary are the main countries. In all these cases the climate is one of contrasts, having long hard winters with plenty of snow, bright springs, fairly dry summers with ample sunlight and hot harvest season.

The soil is mainly deep black loam, of vegetable and animal deposits, thoroughly decomposed and converted.

The ***weakest dry wheats*** are grown in the South-West of North America, in the west of South America, and in parts of Asia. They are white in most cases, and have a ricey brittle nature and thin skins, except where the strength has been impaired by damage to grain structure, such as frost and sprouting. The climate is too even, too hot, and too dry throughout the year. The soil is usually either sandy, rocky, and stony, or of too superficial a nature.

The weak, soft, dense wheats are produced in New Zealand, Great Britain, and similar parts of Europe. The climate is a damp one, with mild winters, large rainfall, warm moist summer and harvest season. The soil is largely clay or reclaimed land, of a heavy nature. Medium wheats, either

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red or white, are grown in soils and climates midway between those just mentioned. The countries are mainly South-West of America, the Argentine, Turkey (Danubian Provinces), Roumania, and parts of Austria, India, and Australia.

THE WORLD'S WHEAT CROP IN QUARTERS.[1]

Country and Continent.	1913.	1912.
EUROPE.	Qrs.	Qrs.
France	40,000,000	41,746,000
Russia, European, 63 Governments	98,900,000	78,090,000
„ Asiatic, 26 „	24,000,000	22,250,000
Hungary	18,000,000	21,220,000
Croatia and Slavonia	1,500,000	1,858,000
Austria	7,000,000	8,717,000
Herzegovina and Bosnia	400,000	374,000
Italy	25,000,000	20,425,000
Germany	18,500,000	20,589,000
Luxemberg	90,000	83,000
Spain	14,000,000	13,744,000
Portugal	1,000,000	1,000,000
Roumania	10,500,000	11,194,000
Bulgaria	8,000,000	7,981,000
Servia	1,600,000	1,800,000
Turkey	10,000,000	17,000,000
Greece	650,000	700,000
United Kingdom	7,500,000	7,175,000
Belgium	1,900,000	1,921,000
Holland	650,000	690,000
Switzerland	440,000	398,000
Sweden	900,000	950,000
Norway	35,000	39,000
Denmark	500,000	469,000
Cyprus and Malta	300,000	320,000
Total—Europe	291,365,000	280,733,000
AMERICA.		
United States	91,000,000	91,287,000
Canada	27,000,000	24,905,000
Mexico	1,200,000	1,200,000
Argentina	25,000,000	24,900,000
Chile	2,200,000	2,250,000
Uruguay	1,200,000	1,250,000
Peru	650,000	700,000
Total—America	148,250,000	146,492,000

[1] Reproduced from the "Dornbusch" list published in *The Miller*, September, 1913.

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Country and Continent.	1913.	1912.
ASIA.	Qrs.	Qrs.
India	44,785,000	45,797,000
Persia	1,800,000	2,000,000
Japan	3,400,000	3,211,000
China	700,000	700,000
Total—Asia	50,685,000	51,708,000
AFRICA.		
Algeria	4,000,000	3,402,000
Tunisia	700,000	530,000
Egypt	4,000,000	3,869,000
The Cape	300,000	300,000
Total—Africa	9,000,000	8,101,000
Australasia	11,100,000	10,800,000
New Zealand	800,000	642,000
Grand Total	511,200,000	498,476,000

APPROX. 1911. WORLD'S WHEAT AREAS IN ACRES.
(Principal countries.)

Russia, Siberia, Poland	60,000,000
Hungary, Austria, Turkey-in-Europe, Germany	40,000,000
United Kingdom	1,500,000
Rest of Europe	22,000,000
India	26,000,000
United States	45,500,000
Canada	10,400,000
Argentina and Uruguay	15,000,000
Australia	6,000,000

The following lists of wheats are arranged in special order under headings of *strength*. The somewhat elaborate grading, and varieties, at the native grain ports of the respective wheats, are usually merged into a few on this side, for convenience of buying, and because also, when the different wheats of the world are brought together into the open markets here, slight differences (and the many centres from which the wheats are drawn), causing the local sub-dividing abroad, are lost sight of or ignored. The main natures, characteristics, and qualities demanded of each nationality are the points upon which they sell. The tables do not deal with every variety, but with main grades and varieties. In this necessarily abbreviated *résumé* of the world's wheats a fair average of all percentages has been aimed at.

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STRONG WHEATS.

Grain.	Colour.	Structure.	Average quality gluten.	Avg. % moisture.	Avg. weight bushels.	Avg. flour yield per cent.	Main impurities.	Per cent. of impurities.	Condition and uses.
No. 1 Hard Duluth .	Red	Hard, mellow	Very high	11	62	71	Cockle, spelt, chaff, oats	3	World's strongest wheat.
No. 1 Northern Spring	,,	,, ,,	High	10-11	62	70	,, ,, ,, ,,	2-3	Nearly equals Duluth.
No. 2 Northern Spring	,,	,, ,,	Good	10-11	61	69	,, ,, ,, ,,	3	Thinner; more waste.
No. 2 Chicago Spring .	,,	Hard	,,	10-11	60	69	Cockle, oats, maize	3	Small, bright, safe.
No. 1 Hard Manitoba	,,	Hard, mellow	Full high	11	62	71	Cockle, oats, spelt	2	Rivals Duluth.
No. 1 N. Manitoba (including Hard Fife)	,,	,, ,,	,,	11	62	70	,, ,, ,,	2	Fine. Equals No. 1 N. Spring.
No. 2 N. Manitoba .	,,	,, ,,	Good	11	60	70	,, ,, ,,	3	Slightly frosted, weaker than No. 1.
Choice Red Winter .	,,	Mild, dry	Fair to good	11	61	71	Cockle, oats, maize	2	Long, bright, white.
Kansas Winter (hard)	,,	Hard	,,	12	60	69	Cockle, grass, seeds, oats	3	Regular; somewhat ricey.
Western Winter . .	,,	Medium hard	,,	12	59	68	Cockle, grass, seeds, oats, smut	4	Irregular; not in general use.
Choice Azima . .	,,	,,	Full	13	61	70	Rye, seeds, dirt, stones	3	Substitute American Springs.
Choice Ghirka . .	,,	,,	,,	14	61	70	,, ,, ,, ,,	3-4	Substitute American Springs, but not quite so profitable.
No. 2 Azima . . .	,,	,,	Good	13	60	67	Rye, seeds, smut, dirt, stones	5	Fair strength factor.
No. 2 Ghirka . .	,,	,,	,,	14	60	67	Rye, seeds, smut, dirt, stones	5	,, ,, ,,
Saxonska	,,	Dry, hard	Full	13	61	70	Cockle, seeds, stones	3-5	Equals Ghirks; not often available.
Ulka	,,	Hard	Fair	14	60	68	Rye, smut, stones	4-5	New wheat, uncertain.
Kubanka Cones . .	Yellow	Hard, flinty	Good	12	61	67	Rye, dirt, barley, stones	5	Strong, harsh; well steamed and washed.
Hard Hungarian .	Red	Dry, hard	Full	11	62	71	Seeds, oats, barley	3	High quality, bright, regular.

MEDIUM WHEATS.

Michigan	White	Mild	Fair	12-13	61	70	Chaff, seeds, dirt, maize	2	Sound; substitute for English.
Bahia Plate . . .	,,	Hard	,,	11	61	65	Oats, barley, stones	4	Rather coarse, thin, and uncertain. Requires careful cleaning.
Rosa Fe Plate . .	,,	,,	,,	11	61	66	,, ,, ,,	4	
Bahia Blanca . .	,,	,,	,,	11	61	65	,, ,, ,,	4	
Victorian (Australia)	,,	Soft to dry, mellow	,,	9	62	72	Chaff, straw, oats	2	Choice colour, bloom; valuable for use with strong wheats.
West Australian . .	,,	Soft to dry, mellow	,,	9	62	72	,, ,, ,,	2	

Soft Club, Bombay	White	Mild, dry	Fair to good	8-9	62	71	Stones, dirt, dust, earth large seeds	6	Good quality, variable.
Kurrachee, C.W.	"	Dry, brittle	"	8	61	68	Large barley, pungent dust, seeds, weevils, stones, all classes of refuse	8	Thorough aspiration, cleaning, washing and conditioning required. Strong flavour, yellow tint.
Calcutta	"	" "	"	8-9	61	68	Dirt, gram, stones, seeds	6	
Delhi (soft)	"	Mild, dry	"	9	60	69	Dirt, maize, stones, seeds	5	Good bulking, white.
Dantzic	"	Soft, mild	Fair	12	61	69	Chaff, seeds, dirt	3	Mild, useful, coloury.
Conigsberg	"	" "	"	12	61	69	" " "	4	" " "
Rostock	"	" "	"	13	60	69	" " "	4	" " "
No. 3 Spring (U.S.A.)	Red	Hard	"	11	59	67	Cockle, spelt, dust	4	Thin, frosted, waste.
No. 2 Red Winter	"	Mild, dry	"	11	60	70	Cockle, oats, maize	3	Safe, mild, white.
No. 3 Manitoba	"	Hard	"	11	59	68	Cockle, oats, stones	3-5	Much weakened by frosted, shrivelled grain.
No. 1 Soft Canadian	"	Soft, mild	"	12	60	71	Oats, peas, stones	3	Substitute English.
No. 3 Azima	"	Medium hard	Fair impaired	13	58	63	Smut, rye, dirt, stones	8	Doubtful, thin; careful cleaning essential.
No. 3 Ghirka	"	" "	Fair	14	59	63	" " " "	8	
Polish	"	From mild to hard	"	14	61	68	Cockle, rye, dirt, stones	6	Somewhat softer and better colour than Azimas.
No. 1 Danubian	"	Hard to flinty	Fair	12-13	62	70	Tares, stones, seeds	3	Requires good soaking; bright, clean.
Dantzic	"	Mild to dry	"	11-12	60	69	Seeds, barley, oats	4	White, similar type to English.
Conigsberg	"	" "	"	11	60	69	" " "	4	Coloury, similar type to English.
Choice Plate No. 1, Barletta	"	Mild to dry hard	"	10-11	62	68	Black oats, cockle, barley	3-4	White flour, long grains.
F.A.Q. Plate, Barletta	"	Mild to medium	"	10-11	60	67	Black oats, cockle, barley smut	4-5	Works white, variable in quality.
Uruguay	"	Mild to dry hard	"	10-11	62	67	Black oats, barley, seeds	4	White flour, similar to Plates.
No. 1 Hard Delhi	"	Hard to brittle	"	8-9	62·3	70	Peas, stones, seeds, earth balls, etc.	4-5	Large, fine grain; thorough cleaning.
No. 1 Soft Delhi	"	Mild to dry	"	9	61	68	" " " "	4-5	
Hard Bombay	"	Dry, hard	"	8-9	62	71	" " " "	6	Somewhat harsh; requires thorough conditioning.
Kurrachee	"	Dry, harsh, brittle	"	8-9	60	67	Pungent dust, stones, earth balls, and all classes of impurities	8	Strong flavour; must be well cleaned and steamed.
Salonica	"	Dry, hard	"	9-10	61	68	Barley, smut, stones	6	Cheap mixing sort.
Moldavian	"	" "	"	10-11	62	70	Tares, rye, smut	4	Bakes well; heavy sound.
Durum	Yellow	Very hard, flinty, thin skin	"	10-11	61	65	Chaff, dirt, stones, seeds	3-5	Gives great trouble in breaking down; flies on rolls; steaming required.
Plate, Candeal	"	Hard, flinty	"	11	61	65	Oats, barley, stones	4	Poor flour yield; must be thoroughly cleaned.
Plate, Saldome	"	" "	"	11	61	65	" " "	4	

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WEAK WHEATS.

Grain.	Colour.	Structure.	Average quality gluten.	Avg. % moisture.	Avg. weight bushels.	Avg. flour yield per cent.	Main impurities.	Per cent. of impurities.	Condition and uses.
Oregon	White	Mild, dry	Low	10	62	72	Barley, seeds, chaff	2-3	Fine grain, helps flour percentage.
Walla-walla	,,	Dry, brittle	,,	9-10	61	70	Oats, smut, stones, barley	3-4	Indifferent, yellow tint flour.
Blue Stem	,,	Mild, dry	,,	10	61	71	Oats, chaff, barley	3	Good yield, good class.
Californian	,,	Dry to brittle	,,	9-10	62	70	Oats, straw, smut, seeds	3-4	Useful white; good mixer.
No. 2 Soft Canadian	,,	Mild, soft	Fair	11-12	61	70	Maize, chaff, seeds	3-5	Good coloury; sweet.
Chilian	,,	Dry to hard	Low	10	62	70	Maize, chaff, dirt	4	Dead white flour; variable.
New Zealand	,,	Soft, mild	,,	14-15	62	71	Chaff, straw, oats.	2	White. Equals 2nd grade English.
Egyptian	,,	Coarse to hard	,,	12-13	60	66	Dried mud, stones, peas	6-7	Poor quality, dead white.
Goose wheat	Red to yellow	Very hard	,,	11-12	61	65	Maize, peas, chaff	3	Coarse, bad condition; careful tempering required.
Taganrog Cones	Yellow	Hard, flinty	,,	12-13	61	64	Barley, oats, rye, stone	5	Coarse; difficult to mill.
No. 4 Manitoba	Red	Hard	Fair impaired	12	58	63	Smut, seeds, frosted grain	4	Large quantity of frosted, shrunken grain.
No. 2 Danubian	,,	Hard to flinty	Low to fair	12-13	60	68	Smut, rye, tares	6	Thorough dry-cleaning.
No. 3 Plate	,,	Mild to hard	Fair	10-11	59	64	Black oats, barley, smut	7	Growthy grain, occasionally works white.
Californian	,,	Brittle, dry	Low	9-10	60	70	Black oats, smut, seeds	4	Very weak, yellow tint.
Walla-walla	,,	Brittle	Fair	10	61	70	Oats, flint, dirt	4	Fair colour, useful.
Persian	,,	Brittle to hard	Low	9-10	60	68	Barley, dirt, stones, peas	7	Steamed and double-washed.
Samsoon	,,	Dry to brittle	,,	9	60	69	,, ,, ,, ,,	8	Thorough cleaning required.
ENGLISH.									
Red Lammas	Red	Mild, soft	Low to fair	15-16	62	68	Chaff, seeds, cockle, smut garlic	2	Very white; safe.
Nursery	,,	,, ,,	,,	15	62	69		2	Good value; small.
Square Head	,,	,, ,,	,,	15	61	68		2	Average, large, clear.
Blue Cones	,,	Dry to hard	,,	13-14	61	68		2	Fine colour, taste.
Talavera	White	Mild, soft	,,	15-16	62	70		2	First quality, large.
Chidham	,,	,, ,,	,,	15	62	69		2	First quality, high colour.
Essex White	,,	,, ,,	,,	15	62	69		2	Clear, white, fine.
Rough Chaff	,,	,, ,,	,,	15-16	62	69		2	Good, reliable.
Scotch	Red or White	,, ,,	,,	15-16	61	68		2	Soft, weak, large.
Irish	,,	,, ,,	,,	15-16	61	68		2	,, ,, ,,

From the foregoing lists the wheats richest in gluten are: American Spring, Manitoban, Russian. Those most deficient are: Californian, Chilian, Oregon, Egyptian, Low Grade English.

Main characteristics of the various wheat berries, as to size, colours, texture of skins and general appearance:—

English generally are noted for cleanness, nutty flavour of flour, sweetness, and large size with opaque and porous skins. To take one or two of the leading varieties—

Red Lammas is hardy, with a somewhat elongated thin body, heavy, and of somewhat variable quality.

Talavera is a good quality, good-sized grain, average weight.

Nursery.—A red wheat, small grain for native, highly-prized, heavy, capital straw.

Chidham.—A prolific heavy grain of fine quality, round, white, and of even appearance.

Essex White.—Splendid shape, size, and appearance, round and well formed; stiff straw.

New Zealand.—Large handsome grain, round, rather bulky berry, opaque skin, similar to English.

Australian.—Soft to medium structure, somewhat thin-skinned. Good shape and size, beautiful creamy colour, smooth. About the finest-looking wheat grown.

Canadian.—Medium size, fairly plump, smooth to shrivelled appearance (due to frost), transparent skin of medium thickness, bright amber, close, fairly hard. Manitobas and Hard Fyfe varieties amongst the best and strongest wheats in the world.

American (U.S.A.) Wheats.—The spring wheats are very valuable, of top strength, fine colour and bloom. Berries are rather small, plump, smooth transparent skin, of fine amber tint, close hard texture. Duluth is the world's premier wheat up to the present, although best Canadians are running a good second.

Indians.—The system of grading most varieties leaves much to be desired, and consequently the brittle and softer, the red and the white varieties become mixed at times. In the main, they are full-sized, straight, square-ended, of a brittle and fairly smooth texture. The red are a dark fleshy tint; the white of varying creams, some being a beautiful tint when cleaned, of medium thickness.

Delhi, is perhaps the best wheat grown in India; is a fairly soft white, full bodied and uniform.

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Calcutta is usually indifferently graded; being very dry as a rule, it is suitable for mixing with damp wheats, and is specially valuable for its water-absorbing powers.

Kurrachee, both red and white, is very dusty and dirty; amongst the worst wheats in the world in this respect, especially obnoxious because of the pungent odour of its dust. It is square-ended and almost square in section.

Plate.—Mostly of a thin, pointed and hard nature, rather thin-skinned and dark, often indifferent quality gluten. Uncertain parcels, grading leaving much to be desired. Unreliable generally.

Russian.—Nearly all grades and varieties are thin and pointed, dark amber in colour, hard to very hard and flinty in texture, and strong in gluten factor.

Many grades are very dirty and full of foreign seeds and screenings. Odessa Ghirka is thin and small, but of very high quality gluten. Kubanka is amongst the hardest and most flinty wheats known. Saxonska—becoming rare under that name in this country—is the finest Russian wheat.

Diseases of Wheat.

Smut (*Ustilago carbo*)	. Black powder adhering to the ears of wheat.
Bunt (*Tilletio caries*)	. Another form of smut, developing inside grains, and filling them with foul-smelling black powder.
Rust	. Black or reddish-black spots on stem of wheat absorbs solvent juices which ought to nourish growing grains.
Mildew	. A fungus which only occasionally damages crops.
Ergot	. A disease nearly eliminated from wheat.

Scents which taint Wheat.

The odour of *heated* wheat.

The odour of *rotting* wheat (with more than 20 per cent. moisture, temperature between 40° and 100° F.).

The pungent odour of garlic. Garlic is not easily distinguished, when it is the same size as grain. Strong air currents do good if wheat is spread out on floor so as to dry the bulbs and make them light enough to be lifted from wheat. It has been proved that the best method of ridding grain of incipient mildew, "fustiness," and all unpleasant and damaging smells is to

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aspirate strongly and frequently. Follow up by washing, heating, steaming, and last, once more cold ventilation.

The spicy odour of small seed (melilotus), which gives aromatic taste and smell to wheat.

"Frosted" Wheat.

U.S.A., Canada, and Russia (due to rapid and severe changes in atmosphere while wheat is in the ear). Condition—cold. Germ and germ-end soft (laid open by nail) slightly blanched, shrunken and clammy.

Diseases and Pests of Wheat.

Hessian Fly	In America, Canada, and Europe.
Locusts	In South Africa, Cape Colony, Russia, Asia, Australia, India, and South America.
Wire worms	In Europe and North America.
Surface caterpillars	In Europe, North America, and Canada.
Chinch Bug	In U.S.A. and Canada.
Cockchafers, Caterpillars, Corn Beetles, Blight	In all wheat-growing countries.
Wheat weevil	In India, Persia, Asia Minor, and South America.
Mites, Lice, Minute insect life	Common to all countries storing wheat in bulk.

World's Wheat Harvests.

Approximate time of operations.

January	Australia, New Zealand, Chili, Argentine.
February	Upper Egypt.
March	India.
April	India, Lower Egypt, Persia, Syria.
May	Central Asia, Morocco.
June	California, Kansas, and all Winter Wheat States, Turkey, and South France.
July	Upper Canada, Early Spring American, South Russia, Austro-Hungary, Germany, Danubian Provinces.
August	America (Spring Wheat States), Lower Canada (Manitoba), Great Britain, Russia, Poland.
September	Scotland, North Russia.
October	Norway, Sweden.
November	Peru, South Africa.
December	Burmah, Australia (New South Wales), Argentine.

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WHEATS OF THE WORLD AVAILABLE FOR ENGLISH MILLS.

Approximate Dates.

January	Oregon, Blue Stem, Californian, Walla.
February	Oregon, Blue Stem, Californian, Walla, Plate.
March	Argentine, most South America, Oregon.
April	Argentine, South Australia, Victorian, Chilian, Egyptian, New Zealand.
May	South Australian, Victorian, Chilian, Egyptian, Indian, New Zealand, Persian.
June	Indian (Bombay, Calcutta, Delhi, Kurrachee), Persian, Syrian.
July	Central Asian, Moroccan, Indian.
August	Red Winter, Californian, Kansas Winters.
September	Manitoba, Dantzic, Azima, Ghirka, Duluth, Red Winter, Great Britain.
October	Manitoba, Dantzic, Saxonska, Kubanka, Azima, Ghirka, Duluth, Great Britain.
November	Saxonska, Kubanka, North Russia, American all grades.
December	Saxonska, Kubanka, North Russia.

Increasing elevator storage in native lands modifies this table somewhat.

As an indication of the quantity of grain imported monthly, in the month ending April, 1914, it was estimated that the following amounts reached England from the principal countries:—

Russia	1,600,000	bushels.
Germany	280,000	,,
Roumania	38,000	,,
Turkey	2,240	,,
United States	3,696,000	,,
Canada	1,821,000	,,
Argentine Republic	4,547,000	,,
Chili	2,576	,,
British East Indies	295,000	,,
New Zealand		
Australia	3,472,000	,,
Other Countries	206,000	,,
Total	15,959,816	,,

To exactly indicate the proportionate prices of the different wheats imported is difficult, but a fair idea can be gained from the following prices of current wheats for June 1, 1914, sold on the London and Liverpool markets respectively. On the former, the grain is quoted at "per quarter" (495 to 504

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lbs.), and on the latter at "per cental" (100 lbs.); for purposes of comparison all prices have been worked out at "per cental."

Wheat.	London Corn Exchange.	Liverpool Corn Market.
	Price per 100 lbs.	Price per 100 lbs.
No. 1 N. Manitoba	7/6½	7/6
No. 2 Hard Winter	6/11	7/8
Blue Stem	7/10–8/–	—
Walla Walla	7/10–8/2	—
English White	6/11½–7/5	—
,, Red	6/10–7/4	—
American Red Winter No. 2	—	8/3–8/3½
No. 2 N. Manitoba	7/5	7/3
No. 3 ,,	7/3	—
No. 4 ,,	—	—
No. 5 ,,	—	—
Australian	7/9	—
River Plate	7/4	7/2–7/4
Rosario Santa Fe	—	—
New Zealand	8/3½	—
Choice White Kurrachee	—	—
Hard Red Bombay	—	—
Red Kurrachee	—	—
No. 2 Club Calcutta	7/11	—
North Russian	6/11½–7/2½	6/10–7/–
South Russian	6/9–6/11½	

FLOURS AND OFFALS. JUNE 1, 1914.

280 lbs.—London Town Whites	30/6
,, No. 1 Town Households	27/6
,, No. 2 ,, ,,	26/–
,, (Liverpool) English patents	27/6–31/–
,, ,, ,, Bakers	25/6–26/6
Offals.—Pollard (or Sharps)	97/6–100/– per ton.
,, Bran	95/––97/6 ,,

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CHAPTER VI

PARCELS FOR WHEAT MIXTURES.

THIS is a much-debated subject, and so many are the differences of opinion with regard to the results obtainable from certain wheat mixtures, so many are the varieties and fluctuations of the same class of wheat throughout the year, that it is impossible to lay down hard-and-fast rules as to what constitutes the most perfect mixture for whiteness, bloom, or strength either separately or combined. No two kinds of wheat work precisely alike. It is safest to treat every shipment of grain as an unknown quantity and test accordingly. It is necessary to thoroughly grasp the characteristics and general qualities of wheats and also to have a clear insight into the state of the markets, both as regards wheat price and quantity available of any given sort, before an accurate decision can be arrived at in making up a suitable and profitable mixture for the particular class of trade goods required. The capabilities of the cleaning and conditioning plant will also have a large bearing upon the range and quality of wheats it is possible to make up for the grinding mixture. Moisture testers will enable the miller to determine the water content of any abnormal wheat parcel, and guide him in his treatment of the same. With these at his disposal the miller can buy wheats which, whilst being dirty and full of other seeds, yet can be bought at low prices, and containing many good qualities to be utilized in the flour mill. As to how far this can be safely and profitably done is a moot point. A very low-priced class of wheat may be bought, full of gross impurities; live and inorganic matter will be present, and possibly in the storage and cleaning contaminate more valuable classes of wheat. The flour yield may be quite low at the finish owing possibly to thin, frosted, weevilled or immature, heated or sprouted grain, although the parcel contained quite a lot of really good grain. This is bad. Power and machinery have been employed to free it from a large percentage of screenings,

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and the greatly diminished clean wheat is still further reduced in the flour sack by poor yield. Another danger is that of low or dirty grades of known strong wheats, such as Russian or Manitoba. It is assumed, say, that the strength is still there, allowance being made only for the loss in weight and measure. The usual standard strength content is reckoned upon in deciding mixture percentages. The resultant grist is found to produce loaves quite unsuited for the strength and pile desired. The reason will be that the grain of the low-priced parcel was probably damaged by frost or was much below standard through pest ravages or immature growth. The only really profitable low-priced wheats will be those of medium strength, which, containing only an excess of dust and screenings of a more or less harmless nature, still retain their good qualities and yields. Whilst, therefore, the consistent buying of none but the very best wheats cannot be made to pay in this keenly competitive industry, it is also just as useless to attempt to keep your market, which is held only by supplying uniformly high grades of flour and offal, by using none but the " cheapest " grades and kinds of wheat. Parcels of very dirty wheat (and we would lay stress upon the fact the consignments can be " dirty " in two ways: either by containing dry inorganic matter and foreign seeds, which whilst mingling with the grains do not materially affect the strength or other valuable properties for which the parcel has been bought; or by containing damp and filthy refuse, breeding all kinds of injurious growths—and perhaps containing minute insect life—which will certainly attack and rob the grain of many good properties, rendering it very unsafe as a factor in the wheat mixture) should be avoided in small mills indifferently equipped for their task of cleaning these specially bad shipments, and should only be used with care and judgment in large mills thoroughly provided with the *best* cleaning and screening apparatus. The most dangerous grades of wheat to use are the lowest grades of Indian, Russian, Canadian, and Danubian. This may possibly be disputed, and such sorts as Egyptian and Persian quoted against them. But, consider, in these latter we do not look for strength or for many good qualities of any kind. In strong wheat such as Russian and Canadian, we are expecting a certain percentage of this feature, and are the more led astray in our calculations when the grade is so low that it contains a great excess of frosted or deteriorated grain. In the case of Danubian and

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Indian they may either be very heavily " diluted " by rye or cockle seeds, and in the latter eaten up with weevils or choked with sand and dust. The buyer is safe to assume that parcels of wheat of small plump to large grains, with bright skins of a clear, firm surface, and fair average weight, or grains of a thin nature, but otherwise good, will give him satisfaction in the mill; whilst wheats of a leaden, dull skin, of a thick opaque nature, or shrivelled, thin and dark grains of a cold and clammy texture, are best avoided, or at least treated with great caution. Garlic or aromatic seeds in a parcel of wheat will give the miller great trouble. The former are often found in first-class samples of native wheat, and the latter in otherwise good specimens of some well-known Asiatic wheats. In the main the points against the use of the " cheapest " wheats are: (1) Cost and time of cleaning out of all proportion to resulting quantity of clean and conditioned grain obtained. (2) Disposal of screenings of a very troublesome nature. (3) Risk of spreading pests and contamination to other better wheats in the plant. (4) Flour-yield diminished and degraded and offals of an indifferent quality (broad bran probably less). (5) Wear and tear of flouring plant greater. (6) Risk of loss of *Trade*.

Weighing the pros and cons of this vexed subject of " to buy or not to buy," the miller arrives at the happy medium of wheats most suited to his district and his customers, and to the plant at his disposal and gets a profit along with a maintained trade or custom

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CHAPTER VII

MILL PLANNING AND CONSTRUCTION

THE best situation in choosing a site for a flour mill is on a dockside or in direct communication with road, rail, or water. Raw materials can be readily obtained and finished products dispatched. The shape and size of the site must then be decided.

It will be economy to purchase additional land in the one block, so that expanding trade can be met by fresh buildings at a minimum of land-purchase expense. "Future extensions" necessary, to a miller already sorely handicapped for space, is a constant source of worry. We will assume that the site chosen is practically rectangular (see Fig. 4), and that the frontage facing the dock or other waterway, is separated from it by a wide quayside and roadway for the general convenience of road and rail traffic. This will drive the receiving department back some 100 feet, say, from the water-line. This space must be bridged or tunnelled in order to convey the wheat from the steamer's hold to silos. To accomplish this, a movable ship elevator, or pneumatic intake plant, will be necessary, attached to either land tower or travelling carriage. In either case this must deliver the grain on to a band conveyor leading into the Wheat Receiving Department.

The main features of mill-planning are: (1) The forward movement of the stock with no wasteful rehandling or return. (2) Direct access to and from all the means of transit. (3) Central power station for even distribution of power, thus, in steam plants especially, minimizing the loss due to shafting and the friction of power transmission. (4) Good light and air space between buildings—the local bye-laws will govern this to a large extent. (5) Accessible administrative block and offices. (6) All loading-in and loading-out

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to be under cover, to save spoiling stock and to give protection to carters. (7) All water intake, waste discharge (condenser and steam-raising water) to be taken from the dock, to be first passed through properly constructed wells

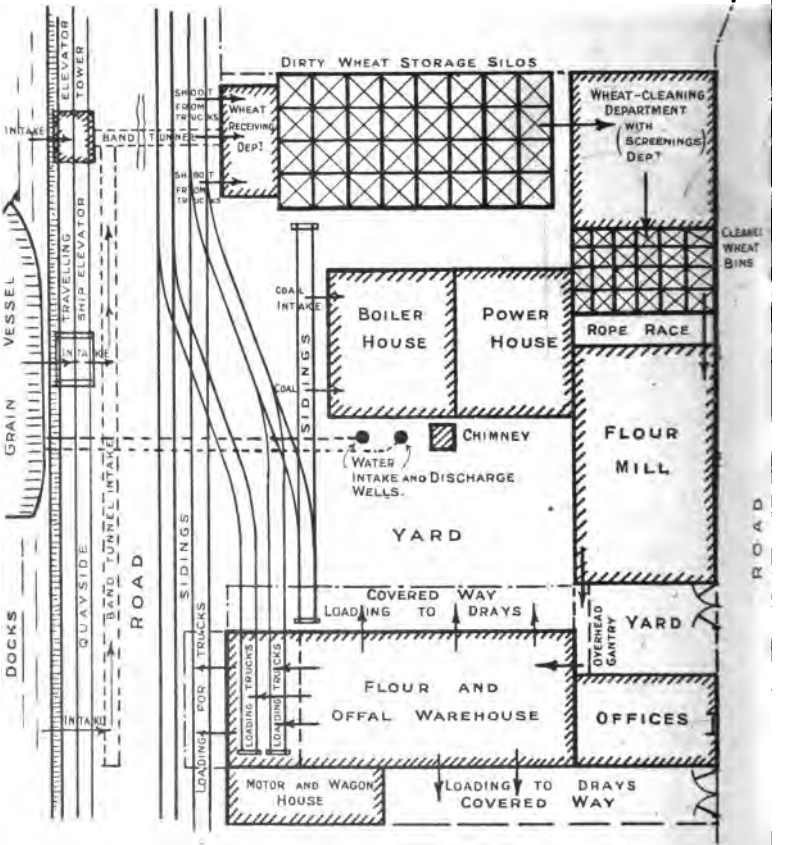

FIG. 4.—GROUND PLAN OF PORT MILL PREMISES.

and filters in yard. Before being returned to the dock, this water should be well cooled. (8) Conveniences and sanitary arrangements should be kept clear of all the manufacturing sections. (The baking and test rooms are usually attached to the office blocks.) (9) Provision must be made for motor

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and waggon housing. (10) The sprinkler installation is advisable for all but the silos. A central elevated tank for water pressure to this is necessary, situated at least 15 feet above the highest elevator-head.

Dealing now with each department in rotation (see Fig. 4). The Wheat Receiving House, besides receiving grain from the gantry intake bands, is required to take from trucks running on sidings alongside the buildings frontage. The wheat is shot through a wall-hopper and picked up by the elevator to join the foreign wheats, and be subjected to a fairly thorough dry-cleaning and weighing before being run into the silos. Owing to the peculiarly tall types of machines used in this department, the floors are usually deep. Dust-extract plants are necessary. The author feels sure that a good deal in this direction remains to be done before this department is safe from dust and explosion dangers. The next building is the silo, or collection of wheat bins. This term is usually applied only to the store for dirty or crude wheat in bulk. It can be composed of either timber (brick or corrugated-iron cased), ferro-concrete, or steel, each type having special features, dealt with elsewhere. Very careful attention must be paid to the foundations and general structure of these buildings. The movement of large masses of grain imposes dangerous live loads upon them, with strong bursting tendencies. The shifting of the weight of grain from one area of the silo to another, during wheat changing, imparts a distinct see-saw action to the structure. In emptying from a compartment also the movement gives rise to sharp drops of masses of grain, tending to produce a hammering effect, likewise disturbing to the stability of the building. With doubtful soils and sub-soils it is best usually to use ferro-concrete piles carrying the whole of the top structure. There is no danger of weakening from after-decay, and they prevent unequal settlement and side movement even on clay and silt sub-soils.

The governing factors in planning these silos are: total weight of grain to be stored; maximum and minimum size of parcels to be kept in separate compartments. The nature of wheats bought and the number of them will have a bearing in determining the size of the bins. A silo should have a number of primary compartments for the reception of large parcels of "crude" wheat (from 500 to 1000 ton lots), and a number of secondary or smaller bins for small local native

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consignments of wheat, for turning over or mixing, and for supplying the dirty-wheat mixture to the cleaning department. In wood-wall silos, with compartments of a uniform size throughout, it is better not to exceed a medium size, say about a 9′ × 9′ as a maximum, because whereas the total storage available at such sizes, for a variety of wheats, might if divided into a lesser number of larger bins result in the last remaining bins being only half filled, and yet not available as a store for fresh arrivals of different classes of wheat. For many reasons, two kinds of grain must not be stored together at this stage. Other items are: local bye-laws with respect to height, and ground area available; nature of soil; required grain-handling facilities for intake, delivery and "turning-over." The cheapest and perhaps most popular form of silo at present is the American "wood wall." It is built up in the following manner. A broad-spread pile-supported raft of concrete is first made. Upon this is usually built a brickwork shell whose main duty is to protect the silo proper from the severity of the weather. Only the base is designed to take any of the weight of wheat stored. Within the area thus enclosed are rows of c.i. columns. Upon these is placed the steelwork frame, forming the main supports for the steel hopper-bottoms and the spiked timber walls of the bin compartments. These walls are formed of laminated layers of timber "bricks" in section from 2½″ × 2½″ to 6″ × 4″. Long spikes driven through two or three thicknesses form the "mortar." The walls always project about 6 inches at the intersection, thus forming a very strong joint. The outer corners, usually a source of weakness in many structures, is one of great strength in this system. All woodwork of this description is, however, liable to warp and shrink. A 6-inch clearance is necessary between the timber and the outer brick shell in order to allow of any slight departure from the perpendicular, without thrust upon the brickwork. This latter has very small strength as regards its safe resistance to such pressures, as evidenced by several bad collapses in different parts of the country in recent years. Owing to the peculiar construction of these bin-walls, they will shrink 6 inches in, say, 70 feet. The top bandway and flooring must therefore be constructed quite free of these, being supported upon steel joists run from wall to wall (see Fig. 5). In many respects this type is the best of all wheat storage.

The good points are: They do not sweat inside, do not

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communicate a change of atmosphere from without, the wood being a bad conductor of heat or cold. A fairly even temperature is consequently maintained within. Vermin-proof if timber well-seasoned. Enormously strong at the

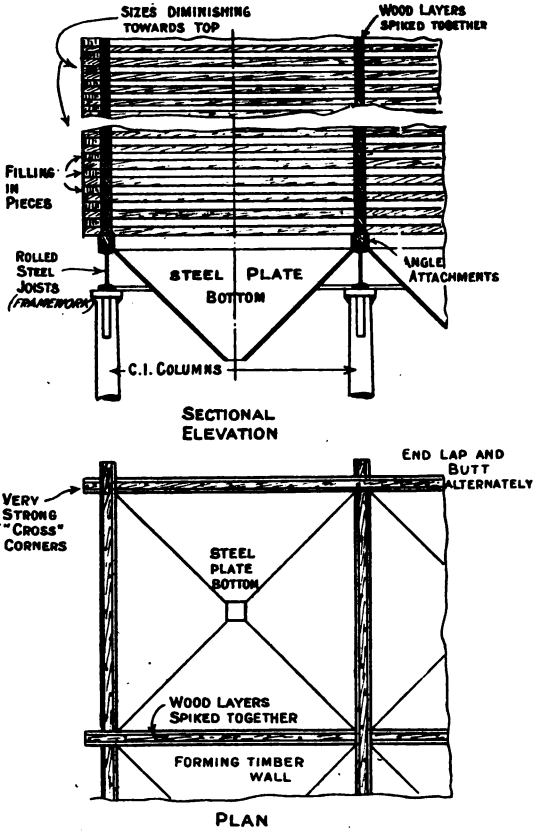

FIG. 5.—WOOD-WALL SILOS.

corners, very tenacious, and offers good resistance to the bending tendency due to the grain pressure.

Bad points.—It shrinks in height, and is liable to warp slightly out of truth. If enclosed or encased in corrugated iron, the sheets must be hung freely over one another or they will buckle. It is usual to limit the size of bins to between

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8 and 10 feet square, and height to 80 feet. The approximate cost, without the shell structure, is £33 per 100 qtrs. capacity.

Silos have been made in the first case as part of the mill building, one section being filled with bins of the match-boarded and battened style, with hoppered bottoms also of match-boarding. These have fallen into disfavour, being quite unfit for the storage of large quantities of grain. They are still used in some mills for the cleaned wheat and blending sections, and for grinding bins. They are not strong enough to withstand any large pressures, and are apt to harbour vermin beneath the corners of the wood hoppers. Steel silos, looking somewhat like steel boilers grouped together on end, are most in favour in the U.S.A. and Canada. They have the advantage of rapid erection upon a strong concrete base or sill, and are very strong for their weight, provided scaling does not ensue. They have no protective covering. They somewhat resemble a huge steel "honeycomb" with "cells" varying from 12 to 20 feet diameter, angle-cleated together, and from 80 to 100 feet deep, are practically fireproof and vermin proof. Their disadvantages are that they conduct the frost of severe winters to grain somewhat quickly, and, as they have latent heat and moisture, sweating is apt to follow. They are usually composed of compartments too large for the reception of any parcels but those intended for primary storage. The approximate cost is £40 per 100 qtrs. storage capacity. The type which bids to take the lead for all large installations, is the ferro-concrete or steel-concrete silo. The principle upon which they are made is that of a grill or net-work of steel rods encased in well-mixed concrete and cement. The walls, floors, tunnels, and top band-race are all in one homogeneous mass, and gain enormously in strength by this means. The rigidity is imparted by the concrete, and the tenacity or resistance to bending and thrusting stresses, by the steel reinforcing rods. This type is capable of adaptation to almost any shape and size of compartment. The Figs. 6 and 7 serve to illustrate the two most popular schemes, the circular and the rectangular. The average thickness of the compartment walls is usually 6 to 7 inches. The circular bins are 20 feet diameter for "primary" storage, and 10 to 12 feet diameter for "secondary" storage. It is usual to make the square bins of about 10 to 15 feet sides. Given suitable piling and rafting, it is possible to run these up to 120 feet. As will be seen, they are equipped with bottom bandways,

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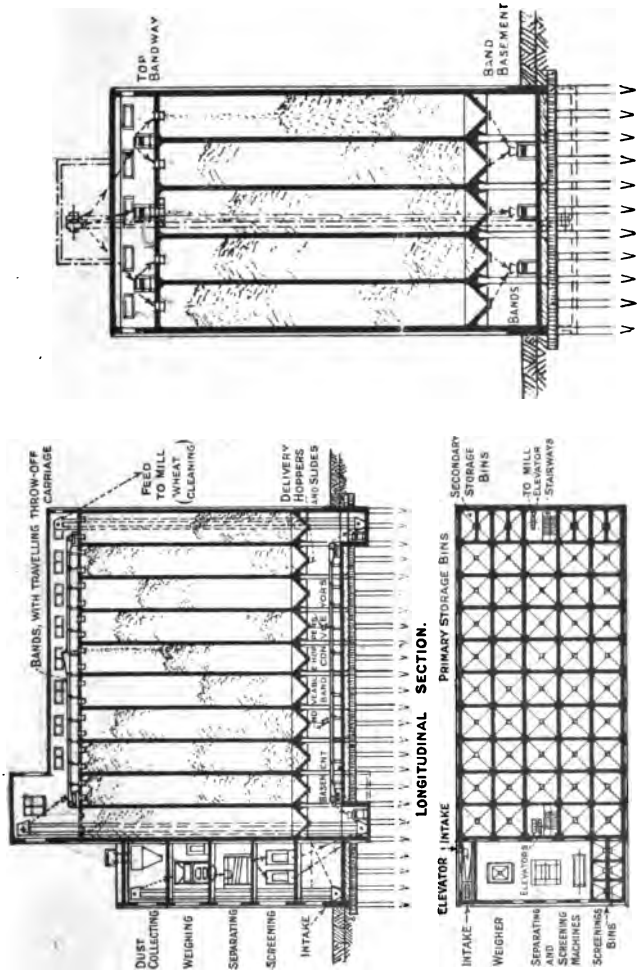
elevator pits, top bandways and elevator tower; suitably treated, they should be an imposing feature of a flour mill



SQUARE OR RECTANGULAR BINS.

FIG. 6.—FERRO-CONCRETE SILOS.

premises. If the cement finish inside is of well-mixed materials, it will be very clean and smooth. Dusty faces only occur where careless mixing has taken place. It does not readily

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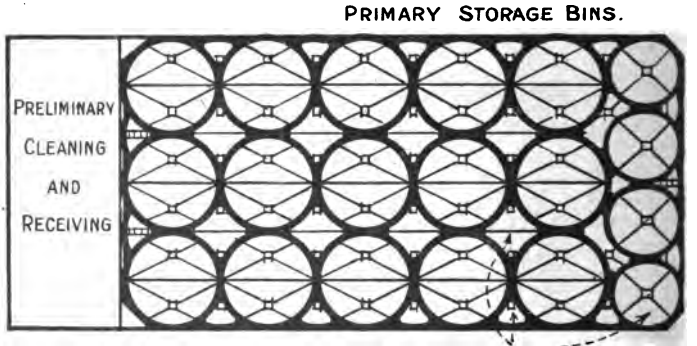
sweat, or transmit changes of temperature. It is quite impervious to rain, frost, or fire, or vermin. The cost is usually £40 per 100 qtrs. capacity.

The next building is the Wheat Cleaning Department. It contains the dry-cleaning, with powerful and efficient dust-collecting, steaming plant, washing, drying, and conditioning plants. Arrangements must be made for the isolation of these sections, and for the disposal of refuse extracted from the wheat on the dry-cleaning—waste, sludge, stones, etc., from the washing and conditioning. Lofty and well-lighted floors are a necessity. Brick walls, timber floors, rolled steel joists,



PLAN.
CIRCULAR BINS.

FIG. 7.—FERRO-CONCRETE SILOS.

and c.i. columns are most suitable, both here and for the mill and warehouse. There are several reasons for this choice. In the first place, whilst a plant is in course of erection it is often necessary to leave holes in the walls and in the sections of the floor, say an end bay, to facilitate the erection of machines. Shafts and wall-boxes have sometimes to be moved. Few mills exist in which, from time to time, spout alterations are not necessary to suit an extended or diverted flow. Cutting floors and new attachments are necessary. If the walls and floors were in ferro-concrete or material of a like nature, this would speedily become a serious nuisance. Iron-framed machines running directly upon concrete floors would be very noisy and possibly vibrate badly, owing to the nature of

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the machines used. This department is usually six stories high. The cleaned wheat or blending bins are often contained within this building. The most suitable type is the timber wall. The peculiar state of the wheat, often containing an excess of moisture, renders an absorbent material, such as timber, a necessity if sweating is to be avoided. A reference to the block-plan of the mill will show that the rope-race divides the wheat-cleaning department from the mill. It is a good arrangement in more ways than one. It is the centre of power distribution, the shafting running through the mill on the one hand and through the wheat-cleaning and mixing on the other. It forms a firescreen between these two departments. It serves as a tower carrying the elevated pressure tank supplying the washing and sprinkler installations. All communications between the wheat-cleaning department and the mill must be made by iron stairways and gantries, and through double fireproof doors. The flour mill has a proportion of approximately two to one length to width. As this building must be equipped with a central line of elevators, it is best to have a fairly steep roof, with a central ridge and queen-post trusses. The tie-beams can be made to carry open timber platforms, for the inspection of elevator heads. All floors should be fairly deep, the purifier floor especially so. The roller floor must be a sound and solid job if vibration from these heavy machines is to be avoided. Where plansifters are employed the floors carrying them should be composed of 3-inch planks with two layers of cross-boarded inch maple. If it can be arranged, an additional bay will be useful for future extensions.

The next building is the Flour and Offal Warehouse, fitted with automatic flour and offal packers, and a complete set of stock-handling machinery. The floors must be strong, as they have to take heavy loads. They need not be more than 10 feet deep above the ground floor. This floor, however, must be 16 feet deep and equipped with a loading platform for half its area. The remainder will contain the loading-on rails, as the sidings must be run right into the building. Through doors on the wall side of platform, the road lorries and waggons can be fed. It is usual to provide timber-bearing bars round the walls to keep the sacks and bags of stock clear, or from falling into window recesses. The power-house and boiler house can be placed either on roadside or in mill yard, according to fuel supply, whether by road or by rail. As sketch suggests,

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it is advisable to consider the water supplies for both steam-raising and condensing purposes in this connection; both buildings should be lofty and roomy, with ample coal-bunker room and firing space in the boiler house, and floor space to spare in the engine or power house for electric switchboard pumps, etc. The offices should be as indicated, in a prominent position, as regards access by the general public. A weigh-house for road loads should also be provided. In conclusion, the whole scheme of a mill installation, as outlined here, should be made with a view to the forward movement of all stocks and to the general lighting of each department. The blocks, considered architectually, should present a dignified and imposing elevation worthy of an important industry.

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CHAPTER VIII

GRAIN INTAKE AND STOCK HANDLING

In working a mill to advantage and profit it is of first importance that the intake plant should be large enough to deal with big parcels of wheat quickly and efficiently. That it should be equipped with reliable handling machinery, preliminary cleaning, accurate weighing apparatus, and dust extract. The machinery for the handling of grain is: (1) The ship or barge elevator afloat, on rails, or pivoted on a land tower. (2) The suction of pneumatic plant, afloat or fixed ashore in a tower. (3) Horizontal conveyors. (4) Spouts, shoots, intake hoppers, weighers, chains, and hoisting tackle for bagged stock.

Grain Handling.—To take a few details of the *Ship Elevators and Stationary Elevators*. The average speed of the band is 300 feet per minute. The elevators consist of a continuous rubber or leather band running vertically within two plate-metal trunks as in Fig. 8. This shows a ship elevator pivoted on two derrick arms. The top band pulley is larger than the bottom—(1) To have a strong driving grip at the top; and (2) to keep the bottom pulley small so that few buckets are in the wheat heap at once. A standard proportion is about two to one. A deep bucket is used for handling wheat, as Fig. 11, because the grains rebound as the bucket strikes, and only half fill it.

Floating Grain Elevators.—These are employed in docks or large rivers where it is necessary either to lighten the steamer, to enable it to get alongside the quay, or to empty it completely into lighters, where quays are not available. It is now the practice to install a ship elevator and weigh-house and necessary driving gear on board a roomy flat-bottomed vessel, a steel pontoon, and to move it from place to place on the docks as required.

The latest and most costly type of intake plant is the pneumatic or suction intake. It is usually found attached to

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certain of the largest port granaries. With a vacuum created by steam engine the usual power required is 3–4 H.P. per

FIG. 8.—TRAVELLING SHIP ELEVATOR.

ton, as against the 1½ H.P. per ton required for the band and bucket type. The nozzles of the suction hose are

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grasped by the lightermen and thrust into the heap of grain, see Fig. 9. The pneumatic intake is usually attached to a tower. From receiving chambers on either side of this spring the armoured suction hose, usually 6 inches in diameter. These number from four to six, all springing from one main suction trunk connected to the source of

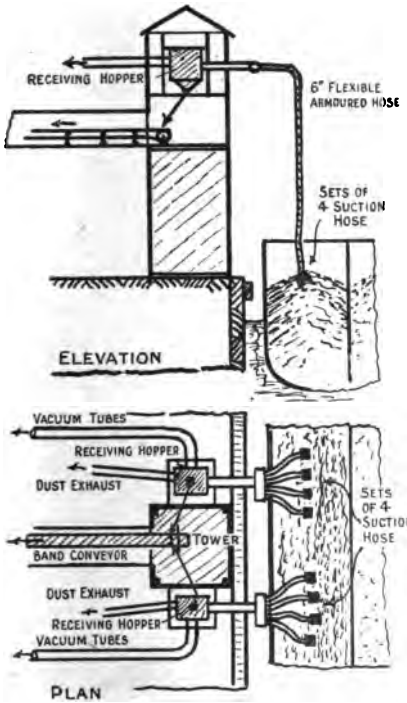

FIG. 9.—PNEUMATIC WHEAT INTAKE.

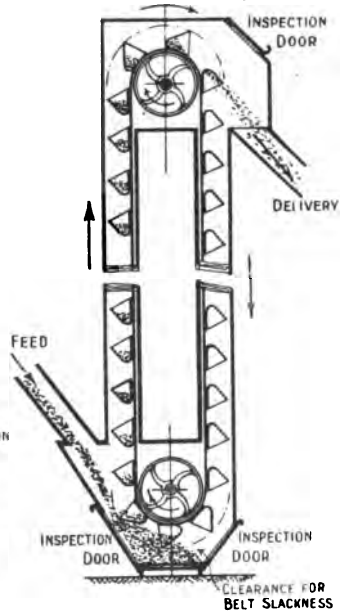

FIG. 10.—SECTION THROUGH ELEVATOR, SHOWING ACTION.

power. The range of each tube is a wide one, a great benefit in dealing with large holds—or a number of compartments. A single 6-inch pipe lifts about 18 tons of wheat per hour. On the nozzle being inserted into the heap of wheat, the grain rushes up the tube and pours into a special air-lock breeches hopper, with hinged flap-valves at the junction of the two ends. The whole hopper rocks, delivering wheat to

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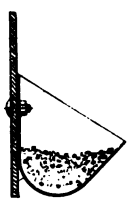
right and left alternately. All classes of grain derive benefit from this system of intake. The rush of air amongst the

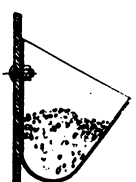
FIG. 10A.—SPENCER'S ELEVATOR—BOTTOM.

FIG. 10B.—SPENCER'S ELEVATOR—HEAD.



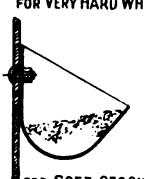
FOR HARD STOCK

FIG. 14.



FOR VERY HARD WHEAT

FIG. 11.



FOR SOFT STOCK

FIG. 13.

ELEVATOR BUCKETS.

FIG. 12.—ROBINSON'S "WADE" ELEVATOR BUCKETS.

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wheat lifts away dust and incipient evils. The filth which is collected from the hopper chambers and deposited in the dust chambers or collectors, is in sufficient quantities to justify its claims as a preliminary wheat aspirator.

Fixed Elevators.—In all departments of the mill, the fixed elevator is used. In wheat intake elevators of long centres, where the wear and drag tends to lengthen the band, the bottom pulley is adjustable. Elevators should be fed, if possible, as per Fig. 10 (bottom, 10A; head, 10B). The buckets most suitable for wheat are as shown in Fig. 11.

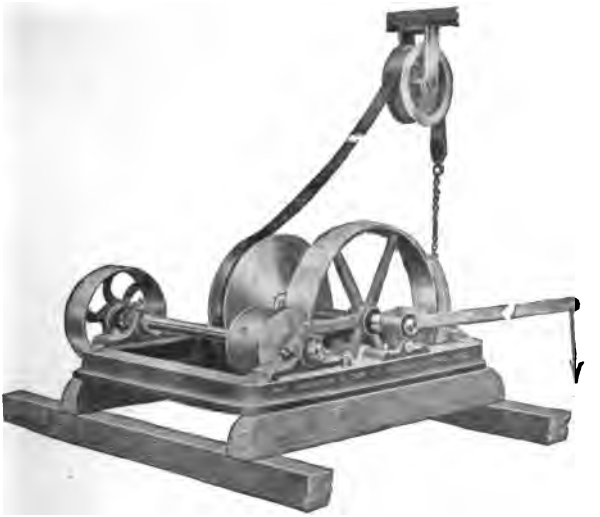

FIG. 15.—ROBINSON'S SACK HOIST.

Fig. 12 is of the close-pitched "Wade" bucket made by Messrs. Robinson, and useful where large capacities are required in limited space; whilst Figs. 13 and 14 are the more shallow type used for flour and soft stock. For dry wheat, leather is used; for wet wheat, india-rubber; and for all the mills' stocks (except the sharp break stock), cotton webbing. Buckets are usually attached to the bands by bolts. The speed of the buckets and band is approximately 200 feet per minute for soft stocks, and 300 feet per minute for wheat.

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For mill stocks a good working list of capacities is—

Size of bucket.	Bushels per hour.
inches.	
3	25
4	40
5	90
6	145
7	200
8	400

CAPACITY OF THE "WADE" TYPE OF BUCKET ON WHEAT.

Length of bucket.	Projection bucket.	Tons per hour.
inches.	inches.	
6	6	30
8	7	60
10	7	100
12	7	120

Sack Hoists, Employer's Lifts, etc.—Sack hoists working in a cathead for outside work, or through trap-doors in the floors of a building, are used for hoisting finished materials

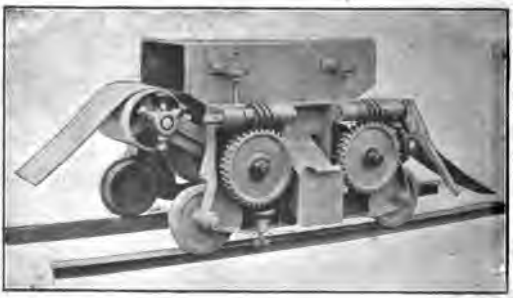

FIG. 16.—SPENCER'S BAND CONVEYORS. TRAVELLING THROW-OFF CARRIAGE.

in the warehouse, and parts of machinery, etc., in various departments of the mill. The average speed is 150–200 feet per minute, and the weights are carried by either straps with chain attachment or chains alone. It is usually fixed well

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out of headroom in the roof, see Fig. 15. A few other types are small electric box-lifts used in deep silos, for the purpose of ready removal of stock and dust bagged off from the dust extract plant, etc., on top floors. In departments of large mills, such as the wheat-cleaning, the mill proper, and

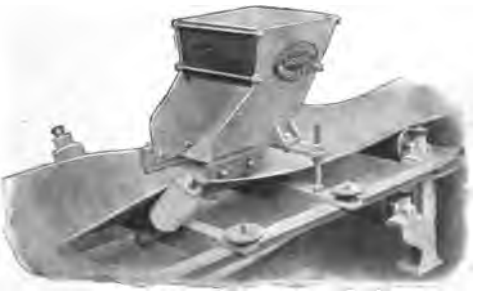

FIG. 17.—SPENCER'S BAND CONVEYOR FEED-HOPPER.

the warehouse, employee lifts are usually now installed. They consist of a continuous vertical rubber band, always slowly travelling. At every 20 feet a foot-bracket and holding handle is attached, running through semicircular holes in all floors. Stepping on or off, for either ascent or descent, is

FIG. 18.—WHEAT BAND IN ACTION.

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quite safe and easy. 'A patent self-acting safety throw-out on the top floor prevents accidents.

Bands.—For horizontal conveying or handling, the band conveyer is best. Its great capacity, combined with the

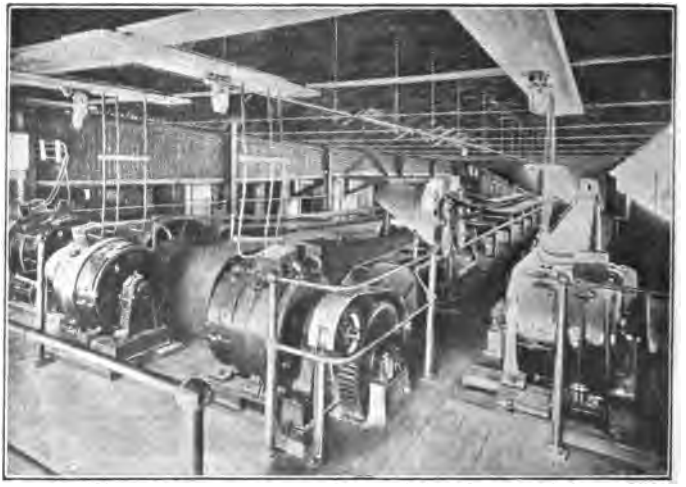

FIG. 19.—BAND CONVEYORS (SPENCER'S).

small power required, places it above all other types. Grain can be carried for great lengths. It can be delivered either from the terminal or shot away, by means of a travelling "throw-off" carriage (see Fig. 16) at any point. The band must be kept from sagging between the carrier-rolls. The rate of travel is governed by "grip" of the grain on the

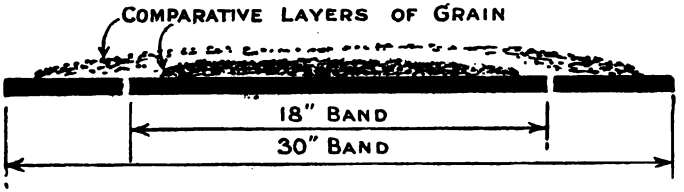

FIG. 20.—WHEAT ON BAND.

surface of the rubber and by the natural inertia of the wheat, as opposed to the backward "drive" of the current of air, created by the speed. The safe working speed limit has been

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fixed at approximately 8 feet per second. Bands are composed of cotton duck covered with a rubber solution, and encased in a rubber covering, stretched and vulcanized. They are known in thickness according to the number of "plies" or sheets of cotton duck employed. The thickness varies with the width of band. *Working* tension should not exceed 25 lbs. per inch per ply. In the majority of cases the band is carried perfectly flat across the rollers, except just at "feeding-on," where the band is troughed by curving-rolls to impart the correct heap to the stream of grain, see Fig. 17. For band conveyor working methods, see Figs. 18 and 19. The power required for a given length and width of band may be taken at 1 H.P. per 50 square feet of band up to 100 feet, all widths, and 1 H.P. per 75 square feet above 100 feet and upwards all widths. Running light the bands take approximately half

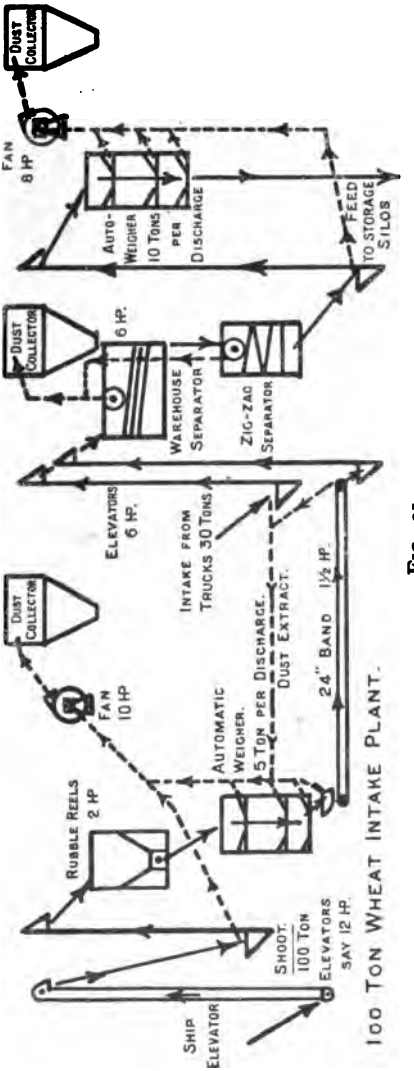

FIG. 21.

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this power. To give an example. A 24-inch band 150 feet long has a surface of 300 square feet. It would, therefore, take, loaded, $\frac{300}{75} = 4$ H.P., light 2 H.P., to drive at a speed of 500 feet per minute. A 12-inch band 50 feet long would take, loaded, $\frac{50}{50} = 1$ H.P., light $\frac{1}{2}$ H.P. The efficiency of bands to worms is as 18 to 1. The capacities of bands is as the following :—

Width of band.	Tons per hour.
inches.	
12	20–30
18	50–60
24	100–120
30	200–250
36	300–350

It will be noticed that the increase of capacity is altogether out of proportion to the increase in width. This is due to the fact that, as Fig. 20 illustrates, the addition of a few inches in width is followed by a much thicker feed-stream. Figs. 21 and 22 will be of use in studying the complete wheat handling and storage plants. A plant of this description is capable of handling automatically any class of wheat. As the power is required alternately and intermittently at the various isolated sections, it will be obviously best to employ electric power for the motors. Electric light is also much to be preferred. The weighers must be absolutely reliable

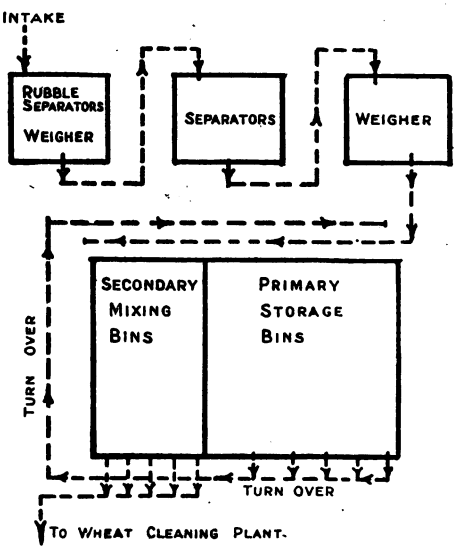

FIG. 21A.

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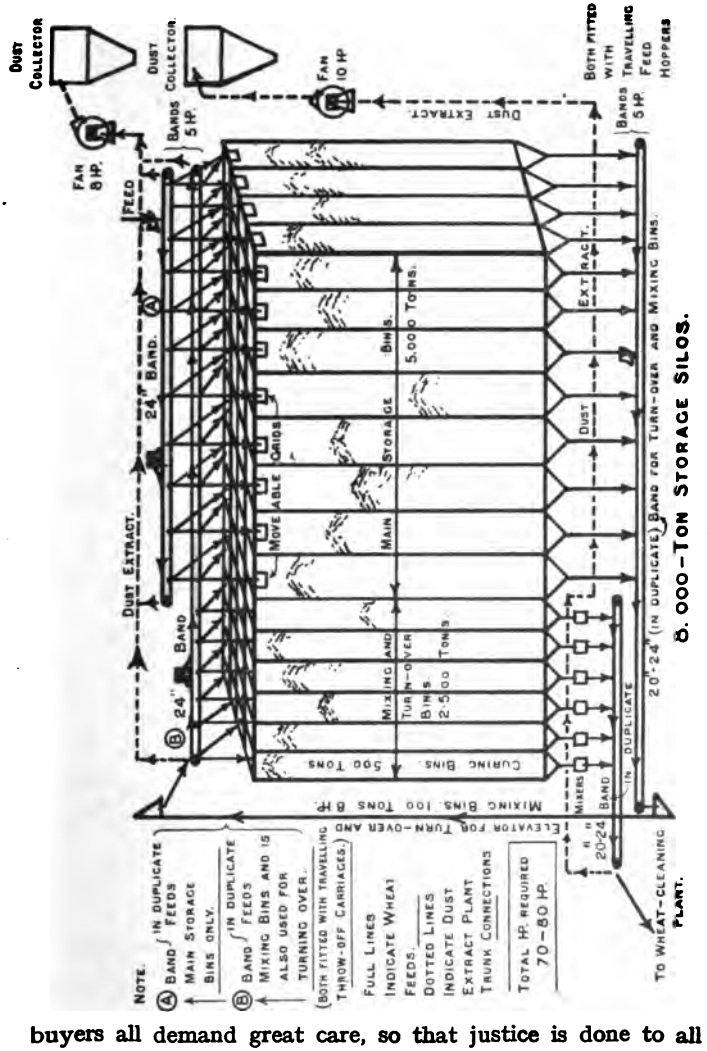
and open to periodic tests. They have to register the quantities passing from the seller to the buyer. Shippers, merchants, and



8,000-TON STORAGE SILOS.

FIG. 22.

buyers all demand great care, so that justice is done to all concerned. It has been found that weighers are most efficient

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in the larger sizes, mainly because the fewer the number of "tippings" per hour, the less will be the chances of inaccuracies. Operatives should see that the self-registering mechanism, attached to the machine, is in order, and that no obstructions keep the brush-valves apart and allow a constant through dribble of grain to escape. The cut-off should be sharp and complete at each discharge. Messrs. Pooley, Avery, and Richard Simon are amongst the leading scale

FIG. 23.—AVERY'S GRAIN WEIGHER.

makers. Some millers prefer the semi-automatic types. These have the weigher vat on one floor, whilst the floors above and below are occupied by the intake and delivery hoppers respectively. The weight of the grain is registered upon a dial, and the operative in charge releases the bottom hopper door by means of a short lever. The entirely automatic weigher is mostly used. Fig. 23 (the Avery Scale) is a good example of this latter.

Screw-conveyors or worms are useful where only moderate quantities of material are being moved. They show to best advantage upon pure, finished stock such as flour. For

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moving sharp or heavy material, such as wheat or break stock, the worm-troughs are made either of sheet-steel or tin-lined wood boxes. While for soft stocks, well-finished white deal

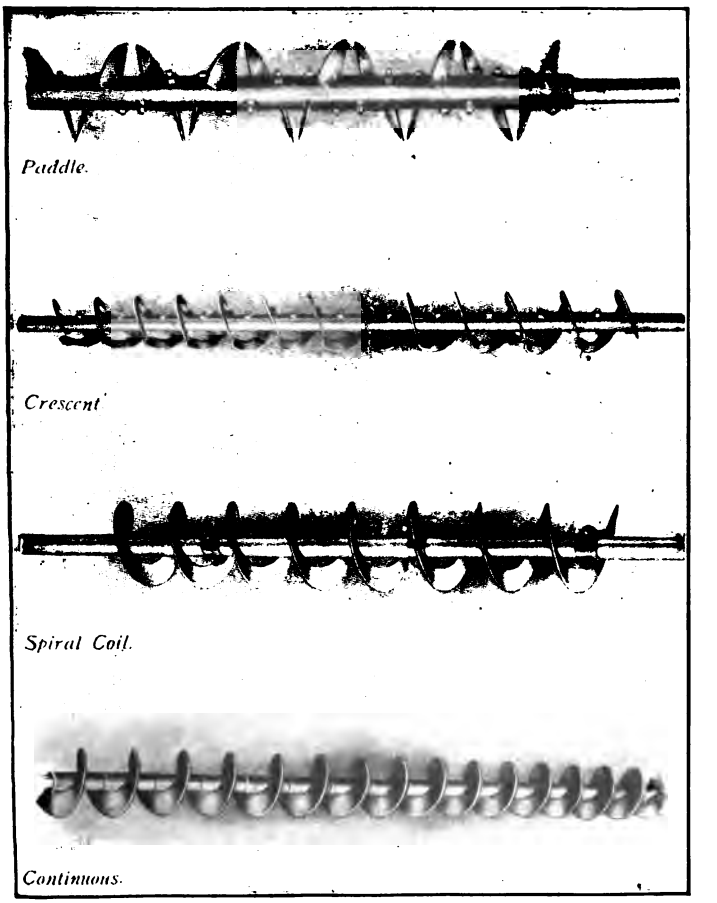

FIG. 24.—ROBINSON'S WORM CONVEYORS.

boxes are best. Many types are employed, each with their special advantages. The type most generally favoured, when incorporated in any milling machine, is the "crescent"

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or "paddle," each blade forming half a spiral, see "crescent" on Fig. 24. They can be reversed, each blade being twisted over to the opposite angle, and thus made to deliver in either direction. Probably the earliest type used was the continuous sheet-iron conveyor. The continuous type is now made in cast iron as "continuous," Fig. 24. The best kind for grain-conveying is the hollow spiral coil conveyor, as Fig. 24. Attached to the spindle by a bracket at about every fourth spiral, it is otherwise quite clear of the turning centre. If a temporary choke occurs, it will remain running, usually leaving a central core of grain, until it can again deliver. The speed for almost all sizes = 100 revolutions per minute. The standard sizes are: 4½, 6, 8, and 10 inches diameter; and capacities are: 75, 120, 200, 380 bushels per hour respectively.

Shoots and Spouting.—In the handling plant, the passage of large quantities of grain at high speeds is the cause of a good deal of trouble. If wooden spouts are used for grain, they should be lined with stout sheet-steel; for intake especially, dealing with wheat, "*etc.*," ample areas must be provided to allow the feed to override minor obstructions. Intake wall shoots or hoppers, provided for receiving from trucks, should be hinged to form a door when not in use, and should be provided with large hopper and shut-off valve and grid in front of the receiving elevator, as a safeguard against sudden overcrowding of the latter. All spouts should be readily accessible, and well provided with inspection handholes.

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CHAPTER IX

PRELIMINARY CLEANING OF WHEAT—DUST COLLECTING AND DUST EXTRACT PLANTS

PARCELS are often arriving from foreign ports of which the term " dirty " is quite a mild one. Unless the coarsest refuse is extracted and the worst of the sand and dust sacked off or exhausted away, as it is discharged from the intake elevator, the handling bands and elevators are liable to chokes. The state of many foreign wheats is a standing disgrace to the respective shipping authorities. The English miller must make adequate provision for dealing with them in a somewhat drastic and costly fashion, at the first handling. All wheat in its dirty state throws out clouds of dust at each " turn-over " on its passage from the ship's hold to the silos. This is often simply powdered earth and dried animal manure, full of microscopic life, incipient pests, and diseases; all waiting their opportunity to attack the precious grain and either kill or materially damage it. Occasionally cargoes arrive which, by reason of very wet harvests, hold leakages, or other obscure causes, contain an excess of moisture. Its presence will be felt in the hold by a tendency of the wheat to heat and deteriorate generally. Heated grain can be detected at once by inspection only. It gives off a disgusting odour or reek, and either appears burnt or brown, or caked together in a grey mildewed mass. The heavy sandy dust, full of germs and filth, the weevils and minute insect life, the many foreign taints and scents, which cling so persistently to the wheat, the ever-present nuisance of large impurities, and all the scum of dirty people and slipshod loading, all emphasize the necessity for a handling plant which is equipped with a preliminary cleaning scheme, if the danger of contamination and multiplication of the first evils is to be avoided. Parcels of wheat can be placed under the four headings, thus—

(1) *First Grade.*—Sound reliable grain up to the quality of the original selling sample. This will probably, however,

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always contain a few bushels of damaged immature or imperfect grains.

(2) *Second Grade.*—Somewhat below sample grade, and includes damaged wheat, either frosted, smutted, or dirty, in excess of sample.

(3) *Third Grade.*—Damp, mildewed, or overheated (or sprouted) parcels, damaged to the extent of 10 per cent.

(4) *Fourth Grade.*—In Indians and other Eastern wheats, badly weevilled and filthy. In American and European, badly overheated or rotting grain, due to wet harvests or leaking holds.

Each grade treated thus: (1) Handled and cleaned in the normal manner. (2) Efficiently and safely dealt with, if a strong aspiration and screening treatment is applied before dispatch to the "dirty wheat" bins or silos. If stored for any length of time, frequent "turning-over" is advisable. (3) Requires very careful and separate treatment and storage in special aspirated bins. Must not be mixed with other wheats until all the taints or incipient growths have been removed. Powerful aspiration and constant disturbance are the best methods. (4) As already indicated, keep them out of the silos or the mill. Attacking and breaking up and turning over the water-damaged parcels, by elevating, by the cool and powerful aspiration, by the tumbling and sifting in the rubble reels, all tend to eradicate the evil. Dispatching these to separate bins, where frequent "turning-over," and, if possible the application of hot and cold air exhaust, will render the damaged parcels fit to be run in with the rest of the mixtures. A systematic repudiation of all parcels below selling sample is leading to some improvement in the relation of cargo to sample.

Such plants are dry cleaning throughout, and except for some sieve screening the whole of the process is accomplished by *aspiration*, or *the application of air currents*. The wheat, after being treated, is still classed as dirty. At best the scum (of the refuse) has only been removed. The principal machine used for this purpose is the *Double-Receiving Warehouse Separator*. Another useful machine is the *Aspirated Reel*. It is particularly useful on Indian wheats which contain a quantity of heavy sandy dust. The disturbance of great masses of dirty wheat creates clouds of floating dust, which, if left unchecked, chokes up bearings and renders the operative's life almost unbearable. Of recent years a system of

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air suction has been applied. In order to make aspiration effective on falling or travelling wheat it is necessary to spread it out in a thin wide stream. The air searches through the rapidly passing grain and lifts out a good percentage of dust and light impurities. Fig. 25 of aspiration explains this principle and its application. The feed is spread well out and double valves form air lock and allow deposits to be removed from tips without disturbing the action of aspiration. The suction is supplied by a fan through the trunks and up through wheat stream. The mixed impurities are lifted away, and, on arriving at the wider part of the trunk, the air expands, loses some of its force, and deposits into screenings tip some of its heavier dust burden. The remainder is carried into the fan and discharged into the dust collector. This principle of separation by air is applied through the whole process of milling. Indian and Russian wheats give the greatest trouble to the preliminary cleaning plant. They often contain a large percentage of heavy sandy dust and impurities of all descriptions. A parcel (of 200 tons) of Kurrachee tested recently contained 2 per cent. of heavy dust and 3 per cent. of an assortment of extraneous matter comprising the following: short and long sticks, tram tickets, maize cobs, straws, cigarette holders, all sorts and conditions of seeds, strings, ropes, papers, coal, coke, sacking, stones and clay balls, two half-anna pieces, and half a tract. Large silos and granaries sometimes keep one compartment for the curing of very damp wheat showing signs of mildew or heating. The damaged parcel is consigned to this, and a sheet-steel air trunk connected to it. Hot or cold air can then be circulated through it until it has reached its normal condition, both in heat and moisture percentage.

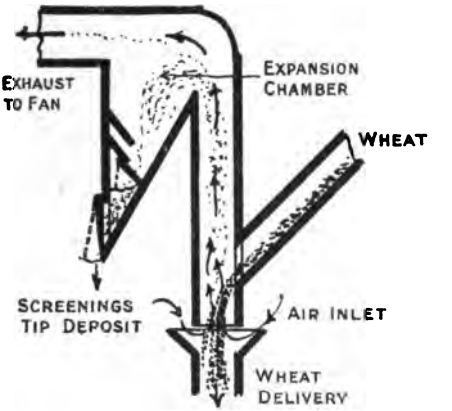

FIG. 25.—PRINCIPLES OF ASPIRATION.

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As already mentioned, the two machines most used in this section are the rubble reel and the warehouse separator. Some very large systems are elaborating the cleaning at this point by the installation of very complete cleaning and screening machinery. The rubble reel, see Fig. 26, is mainly used for removing the scum of the refuse. Simplicity is therefore the leading feature. It consists of a slowly revolving inclined cylinder, covered with strong perforated steel sheeting,

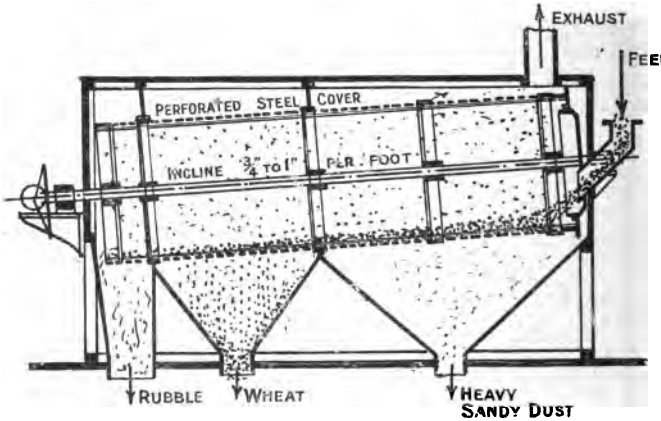

FIG. 26.—SECTION THROUGH RUBBLE REEL.

with several divisions. It is enclosed securely in an air-tight frame, with side inspection shutters. Efficient exhaust is applied to remove the large amounts of floating dust. The separations made are usually hoppered and spouted away. The cylinder, revolving at 15–20 revolutions per minute, and inclined at 1 inch per foot, is so covered that heavy sandy dust falls away on the first division, grain grades away through the second division, and the rubble tails away at the third division spout.

The double-receiving or warehouse separator (see Fig. 27) is capable of much greater capacities, and a more classified series of separations. It consists of a preliminary rubble screen and two main sieves, arranged in double order. These screens are all contained in one frame and are reciprocated by eccentric drives from the main shaft. The preliminary screen tails away only the coarsest rubble and rubbish, and allows all the wheats and the finer refuse to fall through on

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to the head of first main sieve. This is clothed with perforated zinc, tailing away large seeds, sticks and stones, etc., and allows the wheat to dress through to the second main sieve, tailing away over this, the throughs consisting of heavy sandy dust and fine seeds. Self-contained within the separator is a large and powerful fan. By a system of exhaust trunks,

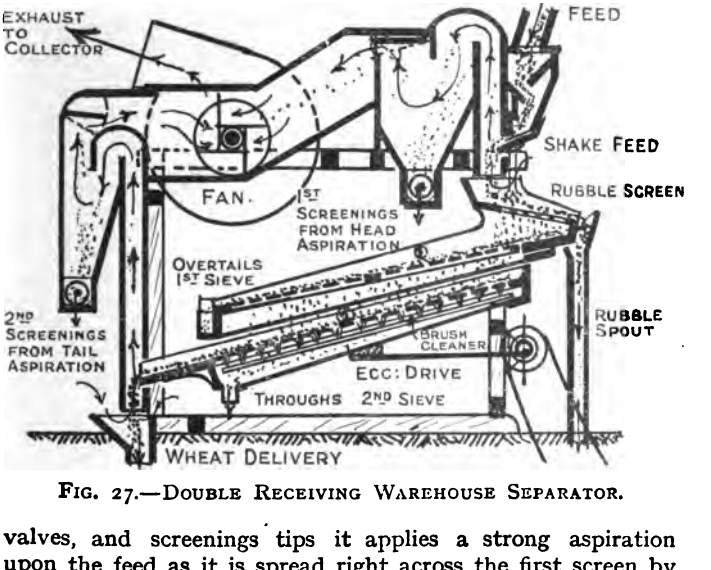

FIG. 27.—DOUBLE RECEIVING WAREHOUSE SEPARATOR.

valves, and screenings tips it applies a strong aspiration upon the feed as it is spread right across the first screen by the feed gate and upon the wheat as it delivers from (in a thin stream) the last sieve. The action can be clearly followed in the diagram. The finest dust, drawn right into the fan, is discharged into the dust-collecting system.

Dust Collecting and Dust Extract Plants.—Dust, in its many forms, from heavy Indian sand to the lightest flour stive, is one of the most serious nuisances in modern milling systems, and strenuous attempts are being made in all departments to efficiently cope with it. A perfect dust collector—that is, one receiving dust particles afloat in air currents in all degrees of pressure and agitation, and passing this air to the open absolutely devoid of dust, whilst avoiding any back pressure on the fan—has yet to be evolved. The old law remains, that "where air will go, dust will go." In the case of our chosen scheme of intake, employing an intake

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elevator tower on the dock or waterside, and isolated from the main receiving-house, the first thing is to keep this free from dust, which, coming off the masses of wheat disturbed in its dirtiest state, will be the most obnoxious and trying to the operatives, and most liable to choke the machines. Fig. 28 gives a simple system of refuse-extract, serving to point my remarks. The most successful attempts so far, to stifle the dust, have been by introducing a suction nozzle at every point of feed and delivery of machines and conveyers, connecting all trunks up to one central trunk and fan. These unit branches are usually from 4 to 5 inches diameter, and have much the same action as the familiar vacuum carpet cleaner. Valves are fitted to each nozzle so that the amount of exhaust can be regulated to suit varying conditions. The suction will be applied at: (1) The intake hopper fed by the movable ship elevator; (2) the fixed elevator bottom; (3) the rubble reels. Here the rolling and spreading action will release thick clouds of dust of a lighter sort which must be drawn away from within the enclosed space of the reel. A strong suction will be necessary here, often applied through two trunks, one at either end of machine; (4) the top hopper of weigher—the weigher vat and the bottom discharge hopper; (5) at the feed hopper of the band conveyor. This will be of great service in mitigating the amount of dust carried by the band

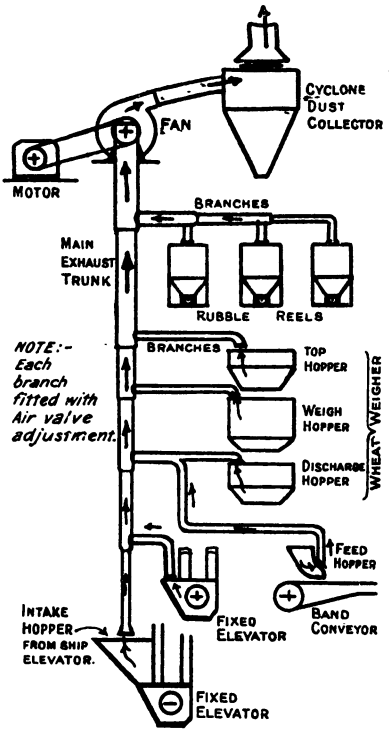

FIG. 28.—INTAKE DUST EXTRACT PLANT.

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to the main receiving house. It is usual also in the large band gantries to install at regular intervals fixed branch air trunks, placed vertically, with a mouth nozzle placed near the floor. Any light refuse and dust falling from the bands can thus be swept to these positions and sucked away at once. The rule applying to the relative sizes of all these trunks is that the sectional area of any main trunk must equal the sum of all the areas of all the branch trunks leading from it. An even flow of air is thus maintained at every point of exhaust application, and the work is more efficient and reliable. Thus a 10-inch diameter tube will work four 5-inch branches, and a 7-inch will work two 5-inch branches. In Figs. 21 and 22 a scheme of dust extract is also outlined.

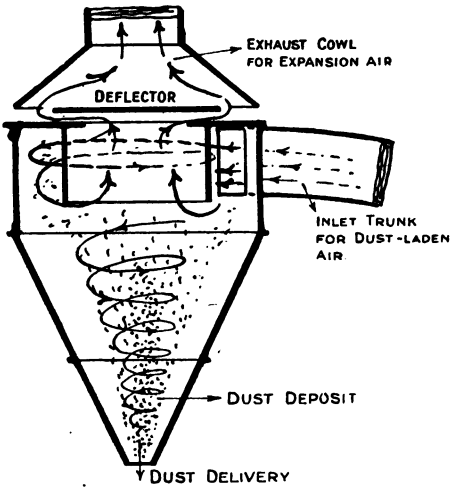

FIG. 29.—CYCLONE DUST COLLECTOR.

Action of Cyclone Dust Collector.—Dust-laden air enters the cylindrical top of the collector at the rapid rate as discharged from the fan. Impinging upon the inner circumference of the top, it is guided round in a rapid whirling circle, forming a whirlpool of air with a centre vortex like that of the ordinary water whirlpool (see Fig. 29). A second inner cylinder prevents the air escaping immediately into the open. At every rotation some of the dust burden is deposited into the vortex and falls through the partial vacuum into the conical bottom of collector and is deposited into sack beneath. A narrow spiral shelf of sheet-iron runs down this cone and further assists the action of the air whirl. The air at top gradually leaks away from beneath the inner cylinder and, striking the baffle plate, is further delayed before reaching the cowl and open air.

Multitubular Filter Dust Collectors.—Since in recent date

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insurance companies have adopted textile dust-collectors, some millers are installing complete collecting plants throughout their systems. Their advantage over the usual cyclone dust collector is, that they can be placed amongst the machines of the mill or wheat-cleaning, if so desired, and not necessarily isolated as in the case of the cyclone. Fig. 30 gives outside views of a typical multitubular filter dust collector, on the blast system, by Messrs. Samuelson & Co., of Banbury. It consists of a number of vertical textile tubes from 3 to 4 inches diameter, fitted into a rectangular framework and exposed to view. A receiving chamber is constructed above these, into which they communicate, and into which also the fan discharges its dust-laden exhaust. Beneath the tubes, and also in communication with them, is a similar chamber containing a set of travelling dust-scrapers, constantly cleaning it of dust and depositing it into a worm-conveyor at one end. The dusty air, upon entering the top chamber, rushes down the filter tubes, and escapes through their walls into the open, the whole of the dust remaining within. To keep the "pores" of these tubes free, travelling wire scrapers, fitted into a frame, constantly disturb the surface, and cause the dust to fall into the deposit chamber below, where, as already described, it is collected and conveyed away.

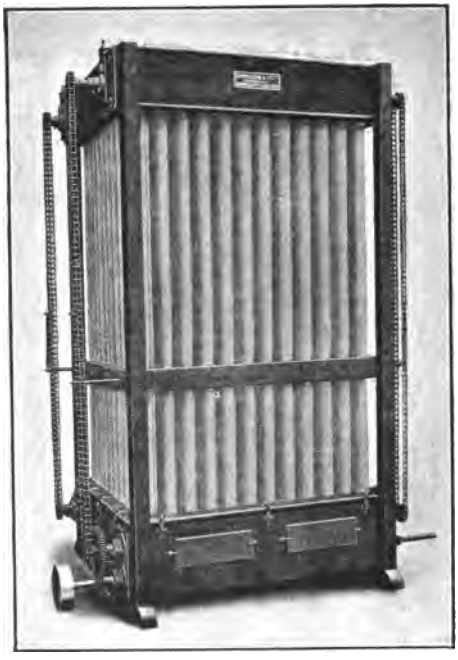

FIG. 30.—BANBURY MULTITUBULAR DUST COLLECTOR.

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CHAPTER X

WHEAT STORAGE

THE pressure of grain upon the sides and bottoms of grain storage compartments and bins has formed the basis for many contradictory theories. The stresses due to the weight of a mass of wheat are constantly changing, as it is either stationary, filling in, or emptying from a bin. The most serious of all stresses set up is the bursting tendency, due to the natural law governing the angle of repose of a heap of wheat. In falling from a height, grain piles up in a heap with sides at an angle of 30°, as Fig. 31. Therefore the "angle of repose" of wheat is 30°. The outward thrust of a pent-up mass is directly in that proportion. The greatest disturbance takes place when the grain is in motion, either emptying or filling. Sudden settlements of the mass set up enormous bursting thrusts and vibrations of the whole structure. In filling, grain runs outward at the angle of 30°, as Fig. 32. A full bin, with the grain to all appearances at rest, really exerts the thrust to almost the same extent as when filling, because the separate grains are always tending to roll away, but are prevented by the silo walls. Wheat, in emptying from a bin, falls towards a "vortex" or centre, as Fig. 33. Once this action is established, the bottom layers of wheat in the bin will be emptied last, as the compartments empty from the top downwards.

Many schemes have been devised to obviate this defect, but with indifferent success in most cases. Grids, inverted cones, etc., have all been tried. The best remedy is to arrange the bins to a moderate size, or, if it is found advisable to employ a number of large primary bins, to construct several hoppers beneath each. This creates several centres for the wheat travel, and is satisfactory for general purposes. Many experiments have been conducted on the lines laid down to determine the exact stresses set up by huge masses of wheat of varying depths. Rather astonishing results have been

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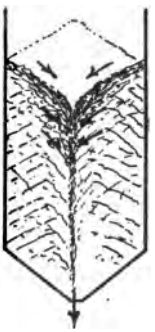
obtained. Although the results of these experiments, conducted by different authorities, have differed in amounts, yet, in the main, the vital principles involved have been confirmed. The pressures upon the bin bottoms do not progress steadily with the increased depth; and the weight imposed is but a fraction of the total weight of the mass. An approximately average rule for calculating this is that the pressure on bin bottom equals the weight of a cube of wheat whose base equals the area of the bin. Thus a bin 8′ × 8′ would have to sustain 8 × 8 × 8 × 50 lbs. = 25,600 lbs. of the total mass, on the hopper bottom. This rule will be found almost exactly correct for an average depth of 60 feet. Above and below that depth the pressures vary considerably. The best demonstration of this is the short extract of grain pressures in bulk, from Donaldson's "Silo Manual." They are determined for a bin of 10′ × 10′ sides composed of well-finished smooth timber, such as the laminated and spiked wood-wall type. The weight of a cubic foot of grain is taken at 50 lbs.

FIG. 31.—HEAPING WHEAT IN ACTION.

FILLING

FIG. 32.



EMPTYING

FIG. 33.

Depth of grain in bin in feet.	Weight of grain in bin in lbs.	Total pressure of grain on sides of bin in lbs.	Weight of grain held up by the friction on sides in lbs.	Weight of grain carried on bottom of bin in lbs.	Pressure on sides per foot run at given depth in lbs.
5	25,000	8,404	3,034	21,966	210
10	50,020	33,616	12,136	37,864	840
20	100,000	126,760	45,760	54,240	3,169
30	150,000	248,560	89,730	60,270	6,214
40	200,000	386,280	139,447	60,553	9,657
60	300,000	692,200	249,884	50,116	17,305
80	400,000	1,024,680	369,909	30,091	25,617
100	500,000	1,373,040	495,667	14,333	34,326

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From these particulars it will be seen how enormous are the forces pent up in deep silos, and how necessary it is to safeguard them against collapse.

See Figs. 4, 5, 6, 7, for silo construction.

Wheat Mixing.—In collecting together a number of wheats from the silos for cleaning and conditioning them as a mixture, they should be thoroughly mixed before reaching the cleaners, in order that all may receive equal treatment. It is also necessary to be able to regulate the exact proportions of the mixture, as this bears directly on the success of the cleaning

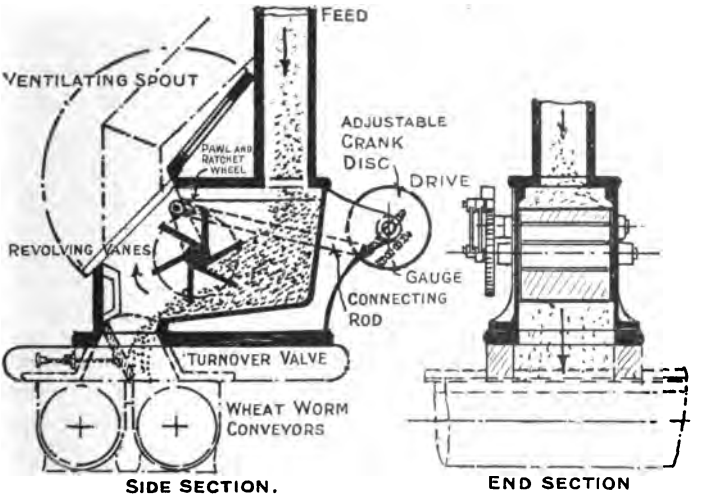

FIG. 34.—ROBINSON'S "MOIR" WHEAT MIXER.

and conditioning. There are no real mixers in the true sense of the word, the machines going by that name being really measurers. As the days of turning over by shovel are past, it remains for the handling plant (the bands, worms, elevators, and spouts) to do the work.

A typical mixer or measurer is that known as the "Moir Mixer" (see Fig. 34). It consists of a receiving box with cast-iron sides and sheet-iron back. The rate of travel of wheat through it to the conveyors is regulated by a revolving cast-iron paddle or collection of vanes, usually six, on a spindle. The spaces between these vanes are like pockets. The wheat entering these pockets is carried forward and under, and

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deposited in delivery spout in front of machine. The faster this collection of pockets rotates, the greater will be the delivery of wheat. The vanes are rotated by a pawl and ratchet, the pawl being fixed to the end of a connecting rod which is reciprocated by a bell-crank lever on the crank disc. The "throw" or length of stroke of the connecting rod can be varied by the screw or disc. The disc or spindle (driven by belt and pulley) revolves at 35 revolutions per minute. This moves the pawl, and therefore the vanes, through a distance corresponding to the throw of the crank, once every revolution. By a graduated scale, the throw of the crank can be increased as greater delivery is required, and a carefully tested equivalent capacity is marked against the scale. The machines are made either single or double.

There are two types of wheat measures. One, the weigher, measures out by weight, taking no note of the bulk. The other, the mixer or measurer, measures out by bulk, taking no note of weight. Both methods are in use and give reasonably accurate results. If, however, the wheats vary greatly in density, the proportions of the mixture or the amounts passing will vary with each wheat, although the apparatus may be set for equal amounts. On the weighers the bulks will fluctuate, and on the mixers the weights will be at fault. Fine, heavy grain, weighing, say, 63 lbs. per bushel of measure, will, on the latter, be in excess of what is desired in the mixture proportions; whilst light bulky wheat of, say, 58–59 lbs. per bushel, will be below the right percentage. To obviate this trouble in abnormal wheats a special wheat measurer or "measure-weigher" has been designed by Messrs. Robinson, in which note can be taken of this varying density, and allowance made for it accordingly in passing wheat. The apparatus can be set instantly to deliver the correct weights of either light or heavy wheats. It is especially useful in measuring conditioned wheat, where the addition or abstraction of water often materially alters the bulk of various wheats. It consists of the usual type of Moir mixer with a box extension above. This top compartment is a valve chamber. The outer indicator lever can be set to any "weight per bushel," ranging from 50 to 70 lbs., thereby moving an inner strickler cam, running the length of the lever spindle and also right across the top of the mixer vanes, and altering its relative clearance accordingly. Thus the greater the weight of the wheat per bushel indicated, the smaller will be the clearance between

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the cam and the vane edges. The wheat is fed into the back of the pockets and heaps up. In working, the wheat is carried forward and *over*, before delivery to spout (in contrast to the usual type of Moir mixer, which delivers forward and *under*). The wheat stream thus piling well above the edge of vanes, dribbles or flows over and is strickled off in varying degrees. The fluctuations in the amount of this overflow being thus regulated, the weight adjustment is kept under control through this alone. The inner turnover valve above the strickler cam can be moved forward or backward; the first position when the apparatus is working, and the second when the wheat feed must be run straight through without the restrictions imposed necessarily by the measuring, thus avoiding a by-spout.

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CHAPTER XI

SCREENING, GRADING, AND DRESSING MEDIUMS

GRADING and dressing covers are made of perforated sheet-steel and zinc, of woven wire in either steel, iron, copper, or brass, of woven silk fabric in many degrees of fineness. The material used varies with the condition and size of stock treated. Any hard, sharp stock will naturally have a greater wearing action than fine floury stock. It can be taken as correct practice to use only metal covers for any stock where some original particles of the wheat berry are present, and recognizable as such. Therefore all scalpers, bran-dusters and scratch stock dressers and dusters should have either perforated sheets or woven-wire covers. All machines treating sharp endosperm particles, as semolina and large middlings, should have coarse silk, termed grit-gauze. Only those machines treating fine middlings, dunst and floury stock can safely use silk covers as their dressing medium. The available sifting surface, or area of perforations in proportion to the entire surface of covers, for the same number per inch, varies thus: for perforated zinc or steel, 40 to 45 per cent.; for woven metal-wire, 50 per cent.; for silk and grit-gauze, 55 to 60 per cent. Woven wire of iron (inoxidizable), steel, copper, brass, and phosphor-bronze is made in sheets 40 inches wide and of varying lengths. The size of mesh is indicated by numbers, giving the meshes per inch. Perforated plates of steel, zinc, or iron have no fixed sizes, neither do their numberings indicate the holes per inch. Grit-gauze is really coarse woven silk, and is numbered to indicate approximately the meshes per inch, measured on the side of an inch. Silk, the most expensive and the most accurate of all covers, is of a special brand, the highest qualities coming from Switzerland, where the conditions of food and atmosphere favour the best development of the silk-worm, thus conducing to the finest silk threads. Both silk and grit-gauze is woven in metre widths. In counting the meshes per inch of silks it is best to count

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the "warp" threads, or across the width of cover. These threads are more reliable than the "weft" threads, being regulated by machinery, whilst the latter are governed by the operative. "Warp" threads run lengthwise with the cover and are double- or treble-stranded. "Weft" threads run across the cover and are single. Silk numbers, to the lay mind, are no guide as to the size and number of mesh. Even those people constantly in touch with silk covers are apt to be misled if the make is not a familiar one, because no two makes agree. Manufacturers issue trade lists of sizes, and these must be consulted upon employing their goods. The finest silks cannot be noted by the naked eye, therefore it is usual to employ special microscopes or silk-counters for the

ENGLISH STANDARD PERFORATIONS FOR STEEL, IRON, ZINC, COPPER, AND BRASS SHEETS (STANIAR'S).

Trade number.	Size, inches.	Size, millimetres.	Trade number.	Size, inches.	Size, millimetres.	Trade number.	Size, inches.	Size, millimetres.
4	1/32	0·90	10B	—	3·65	15A	18/50 (9/25)	9·00
5	5/128	1·0	10½	1/4	3·75	15B	3/8	9·50
5A	1/25	1·0	10½A	—	—	15C	—	9·80
5½	9/128	1·20	10½B	2/13	3·90	15½	2/5	10·00
5¾	1/20	1·25	10¾	8/33	4·00	15½A	—	—
6	1/19	1·30	10¾A	—	4·10	15½	21/50	10·50
6A	1/18	1·35	10¾	1/6	4·35	15¾	—	10·75
6¼	3/64	1·50	10¾A	—	—	16	22/50 (11/25)	11·00
6¼A	3/50	1·50	11	9/33	4·50	16½	24/50	11·50
6½	1/13	1·65	11¼	—	4·60	16½	13/33	12·00
6¾	1/13	1·75	11½	3/16	4·70	16½A	—	12·00
6¾A	—	—	11¾	—	4·80	16¾	1/2	12·50
7	1/13	1·95	12	1/8	5·00	17	—	13·00
7½	3/25	2·00	12A	—	5·10	17½	26/50 (13/25)	13·00
8	1/12	2·20	12¼	3/25	5·25	18	27/50	14·00
8¼	1/12	2·33	12¼A	—	5·50	19	28/50 (14/25)	15·00
8¼B	1/12	2·35	12½	—	5·75	19½	32/50 (16/25)	16·00
8½	3/32	2·40	12¾	6/25	6·00	19½B	32/50 (16/25)	16·00
9	1/10	2·50	12¾A	1/4	6·00	19¾	34/50 (17/25)	17·00
9¼	1/9	2·65	12¾B	—	6·25	20A	36/50 (18/25)	18·00
9¼A	1/9	2·75	13	—	6·50	20B	38/50 (19/25)	19·00
9¼B	1/9	2·85	13½	14/50 (7/25)	7·00	20½	4/5	20·00
9½	6/50	3·00	14	3/10	7·50	21	7/8	22·00
9½A	6/50	3·10	14A	—	7·75	21½	42/50 (21/25)	23·00
9½B	6/50	3·15	14½	5/18	8·00	22	1	25·00
9¾	1/8	3·25	14½	7/25	8·40	30	1¼	30·00
10	7/50	3·50	14½A	17/50	8·50	35	1⅜	35·00
10A	7/50	3·50	15	18/50 (9/25)	9·00	40	1½	40·00

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purpose. Below is a list of comparative equivalents for metal and silk covers. It is taken from an average table and is only approximately correct owing to the great differences in the texture of fabrics and strands. While the wire and grit-gauze numbers give approximate actual meshes one side of

DRESSING AND GRADING MEDIUMS. EQUIVALENTS IN THE DIFFERENT MATERIALS.

Silk trade numbers.	Grit-gauze-numbers.	Wire numbers.	Perforated sheet numbers.
0000	18	16–18 (Steel or iron.)	6
000	24	23–24 (Steel or iron.)	5
00	30	29–30 (Steel or iron.)	4½
0	38	36–38 (Steel or iron.)	4
1	44	42–46 (Steel or iron.)	3½
2	50	50 (Steel or iron.)	
3	56	54–56 (Steel or iron.)	
4	60	60 (Steel or iron.)	
5	64	64 (Brass or copper.)	
6	72	72–74 (Brass or copper.)	
7	80	80–82 (Brass or copper.)	
8	88	88–90 (Brass or copper.)	
9	96	96–98 (Brass or copper.)	
10	106	106–109 (Brass or copper.)	
11	112	112–116 (Brass or copper.)	
12	120	120–122 (Brass or copper.)	
13	128	128–129 (Brass or copper.)	
14	138	138 (Brass or copper.)	
15	148	148 (Brass or copper.)	
16	156	156 (Brass or copper.)	
17	170	162–168 (Brass or copper.)	
18	180		
19	190		
20	200		
21	210		

LIST AS PER MESSRS. JOHN STANIAR AND CO., MANCHESTER.

Silk trade numbers.	Double twist silk.	Treble extra heavy double twist.	Quadruple extra heavy double twist.
	Threads per inch.	Threads per inch.	Threads per inch.
0000	18	—	16
000½	21	—	18
000	25	—	20
00	30	—	22
0	36	—	24
0½	40	—	26
1	45	—	28
1½	50	—	30
2	55	—	32
3	60	—	34
4	64	—	36
5	68	64	38
6	76	68	40
7	84	76	42
8	88	84	44
9	100	88	46
10	113	100	48
11	119	113	50
12	125	119	52
13	132	125	54
14	140	132	56
15	150	140	58
16	160	150	60
17	170	—	62
			64
			66
			68
			70
			72
			74
			76
			78
			80
			82
			84

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an inch of cover, the silk and perforated metal sheet numbers are merely trade, or reference marks, and follow no fixed progression of numbers. The particular notation followed by Messrs. John Staniar and Co. will be useful. In the sheet perforations a great many varieties of sizes and shapes can be obtained, such as " longholes " for smutter cases, " rounded longholes," " oval holes," " triangular holes," stabbed or punched holes, and combinations of these.

In Fig. 35 the relative size of grain to holes, for tailing and grading respectively is shown.

In measuring covers for the purpose of ordering new material, or in measuring machines for new covers, in order to have the silk fitting accurately to the reel or cylinder, the exact measurement of the circumference must be taken, both at the ends and the middle of the reel skeleton. These dimensions must be taken by a reliable steel tape. It is well also to state whether or not allowance has been made for stretch. It sometimes happens that the silks will not stretch evenly, and will not bear evenly all along the bars and ribs of the reel frame. This frequently means that the latter are at fault. It is best, therefore, first of all, to line the bars up truly by taking a straight line or cord tightly stretched from end to end of reel, and then to adjust them to suit this line. In fixing silks on reels or centrifugals, they should be tightly stretched the whole length of the cylinder before they are fastened round the circumference. The tape fitted with eyelets should also be perfectly taut.

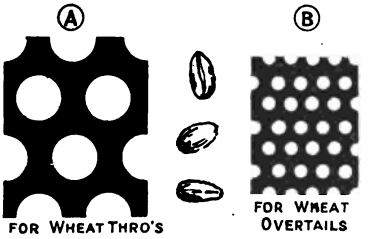

FIG. 35.

Silks should stretch naturally and without distortion, so that the meshes shall remain true and square.

Avoid mounting silks during extremes of dampness, heat or cold. A silk already stretched and rested for twelve hours can be subjected to an additional stretch of a half to three-quarters of an inch. When sufficient tension has been obtained, if there still exists a space between the eyelets, which sometimes happens, through, say, irregularity of the reel caused by the twisting of the arms or rails, do not use any

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force to join the eyelets. It will be better to cover the opening with old silk and some paper underneath, pasting it with wheat-flour paste. Silks are bedded well upon the swans-down covering of the bars for protection against wear. In stretching covers on sieves, as for purifiers, graders, and plansifters, the same care must be exercised to make sure that the surface is perfectly even and taut. Warping and distortion are more fatal to successful d essing in the plane sieves than in the circular sieves (or reels).

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CHAPTER XII

DRY CLEANING OF WHEAT

THE modern wheat-cleaning plant is designed to extract from the wheat not only the dust and stones, but to remove also all substances and seeds other than wheat (such as chaff, straw, large and small seeds, maize, barley, rye, oats, cockle, rape, clay balls, and pieces of metal, etc.).

Light, smutted, and immature grains must be removed without breaking up so as to prevent the possibility of the contents of diseased grains spreading. The beard and light shrivelled tissue often present on the grain must be removed, and the berry polished.

The individual wheat berry will also, in some cases, be smeared with caked mud and other impurities. All these impurities will have escaped the preliminary cleaning in a greater or lesser degree because the heavy and continuous stream of wheat passing over the screens allows only a partial or casual extraction of the grossest impurities in the first instance.

The principal machines used for dry cleaning are :—

(1) *The Warehouse Separator,* either double or single. Extracts rubble, maize, seeds, stones, and dust.

(2) *The Zigzag Separator.*

(3) *Scourer.*

(4) *Cockle Cylinders and Extractors.*

(5) *Barley Cylinders.*

(6) *Grading Sieves or Reels.*

(7) *Automatic Magnetic Separators,* or

(8) *Horseshoe Spout Magnets.*

(9) *Trunk Aspirators and Fans.*

(10) *Brushes* or polishing machines either horizontal or vertical.

(11) *Dust Collectors.*

(12) *Feed Dividers.*

(13) *Exhaust Fans.*

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The removal of impurities by the dry-cleaning process is accomplished by two means, separation by size, and separation by weight. The majority of the machines used are those embodying the sieve principle, reciprocated or rotary. The latter motion approaches nearest the hand sieve action. In all cases these sieve separators, whether single or double, are strongly aspirated, both at head and tail.

It is worthy of note that the perforations of the zinc covers for these machines are in all cases slightly larger than is absolutely necessary to pass the particular substance for which it is designed. The large, rapidly flowing stream of hard grains and impurities rebounds from the blank portion of the sieve and tends to ride over holes it would otherwise pass through. Thus the sieves separate by sizing, and the aspirations applied, lift (*i.e.* separate) by weight.

The sieve separators are placed before the scourers and brush machines in order that, being gentler in action than the latter, they may remove the most friable and harmful impurities before reaching any breaking or rubbing agency.

Cockle Cylinders or Extractors are absolutely necessary machines. However small the percentage may be, if left in the mixture it is bound to show in the finished product, the flour. Reaching the breaks, each black seed will become broken into scores of minute particles, impossible to separate from the flour, and half an ounce of cockle in a sack has been known to reduce the selling qualities of the flour sixpence per sack. Earth balls and clinging dirt must be all removed if flour is to stand the high standard testing of to-day.

Machines which require a good deal of attention and adjustment, and also ample space for the aspiration intake and a constant sweeping around by attendant, will only give best results when standing well clear of all encumbrances. Cleaning machines should be isolated from each other, and accessible from all sides. All working parts of the cleaners require constant careful attention and adjustment. The rapid motion and vibration of the sieves always tend to work the attachments loose, and if the wear of the eccentrics is not taken up as required, and the reciprocation of sieves properly balanced, they will "throw" from side to side and render efficient work impossible. Speeds should be maintained, and the drives should be neither too short nor too vertical.

All bearings, whether on machines or main driving shafts, should be of the self-oiling enclosed type, capable of running

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for a fortnight without attention. There is so much grit and dust about even in the best screening departments which is constantly settling, that any other type of exposed bearing becomes choked with it. Friction, heating, and useless bearings are the result.

Feeds must be kept across the whole width of sieve and run in a steadily moving, thin, broad stream to allow the wind currents to search for, and extract, light impurities, and the sieve perforations to abstract and dress through all wheat or small grains and tail over only the large impurities.

Bags must be hung beneath all tailings, spouts and outlets, and screenings tips, and a handful from each examined now and again to ascertain that no quantity of wheat is tailing over (if so, feed is either too great or sieves are out of balance), and that no small wheat or heavy impurities are being deposited in screenings tips (if so, the air suction of fans is too severe and the valves must be adjusted).

Magnets are placed before scourers to avoid risk of firing and sparking (fire risks.)

The wheat berry skins have been proved so friable that it is not now the practice, as formerly, to scour and brush repeatedly. The brushing is now left until the wheat is ready for the first break, for the final polish. As long as any bran or skins remain, so long will the brush find something to remove. Clearly this can, therefore, be carried too far.

The main feature of the dry-cleaning plant, and one receiving great and greater attention, is the application of aspiration at every possible and useful place in the system. Aeration will always benefit and will never damage wheat, and whilst limits must be placed upon the repeated applications of other cleaning methods, no restrictions need be placed on this.

Dealing with the dry-cleaning machines in order, the first machine is the magnetic separator. The Fig. 36 serves for two machines, as it combines the offices of a feed-divider and a separator. It consists of a feed hopper with an adjustable gate and roller. Beneath this, and incorporated in the frame, is a set of magnets, sometimes electro-magnets, set in plaster of Paris. Below this incline still is the dividing box, cut up into 3-inch divisions by the fixed valve boards. All surfaces are sheet-steel lined. The wheat, entering the hopper, is spread out to the whole width of the roll, before passing the feed-gate. A counterbalance spring holds the gate up to the roller, and can be adjusted so that the hopper

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is automatically filled. The wheat passing in a thin even stream over the magnets leaves its metallic substances there, which are periodically removed by the scraper bucket on the endless sprocket chain, driven from the feed-roller. The stream of wheat, pouring into the dividing chamber, is automatically split up into 3-inch "strips," and falls away to the next machine. The automatic feed-hopper can be applied to either magnets or dividing chamber, separately or combined.

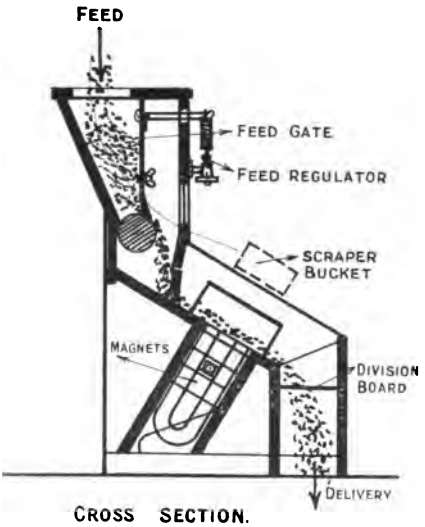

FIG. 36.—MAGNETIC SEPARATOR.

Zigzag or Milling Separator.—This wheat-separator is so termed because its sieves or screens are placed in zigzag order, to obtain the maximum screening surface with the minimum space. It consists of an aspiration apparatus applying suction to feed and delivery, see Fig. 37. It has five sieves: 1, a small side screen with feed spreader; 2, 3, and 4 are main screens; and 5 is a finely meshed screen to sieve away small seeds and sand. The main sieves or screens are reciprocated in pairs, or as a whole, and, contrary to the usual custom, sideways. This enables a steep incline of the sieves to be maintained. It removes maize, barley, oats, stones, large seeds, sticks, clay-balls, fine seeds, etc., which have escaped the warehouse separator. A sample clothing is (perforated zinc being almost always employed): (1) *Shoe screen*, $\frac{3}{8}''$ to $\frac{1}{2}''$ diameter holes; (2) *screen*, $\frac{1}{4}''$ to $\frac{1}{2}''$ diameter; (3) $\frac{7}{32}$ to $\frac{5}{16}''$ diameter; (4) $\frac{3}{16}''$ to $\frac{7}{32}''$; (5) $\frac{3}{32}''$ to $\frac{1}{8}''$ diameter.

Grading Sieves.—The reciprocating sieve or sifter is one of the oldest forms of grader or separator. It is usually fixed in a stout wood frame and reciprocated by a single or double eccentric rod. It is supported from beneath by ash splines or hung up by rods.

The motion or throw is about $\frac{1}{2}$ inch to 1 inch, mostly

short and rapid. The eccentric shaft rotating at 500 revolutions per minute. The sieves are inclined at 1 in 12. The action is to jerk the wheat or other material down the length of the sieve in a broad thin stream so that the finer particles will fall through the meshes or perforations. A tapping arrangement is usually provided to keep these clear and prevent impurities blinding the sieve. Most types of these grading sieves have a blank feed spreader board at the head with a serrated edge or tip, so that the wheat feeding from spout will heap up until it reaches this level. It will then commence to pour in a broad dribble from between the tooth edge of spreader board.

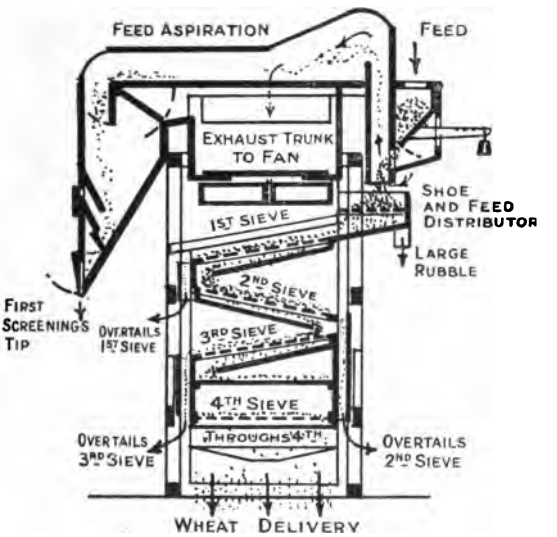

FIG. 37.—ZIGZAG OR MILLING SEPARATOR.

Rotary Graders.—These are worked on the rotary hand sieve principle. The sieve worked by hand has been long recognized as the most searching and efficient of all sifting apparatus, and the rotary sifter follows on these lines as far as is consistent with great capacity. Consists of a sieve box containing either single or double sieves slung up to a frame by four straps or rods. The hangers are adjustable in order that the sieve box may be exactly balanced, see Fig. 38. The rotary motion is imparted by means of a central vertical shaft and a balanced eccentric disc.

Cockle Extraction.—All millers will agree that it pays to go to great lengths to remove cockle, even at the cost of some amount of small and broken wheat grains. The usual

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method of extraction is by means of the cockle cylinder, see Fig. 39. The whole of the interior is indented by a special system. The most approved way now is to drill the indents. The cylinders operate in the following manner. Wheat and cockle is fed into the top end of the inclined, slowly revolving cylinder, and commences to travel down towards the tail end. The feed is spread well out in the attempt to carry it up to one side. The wheat, being larger than the indents, passes

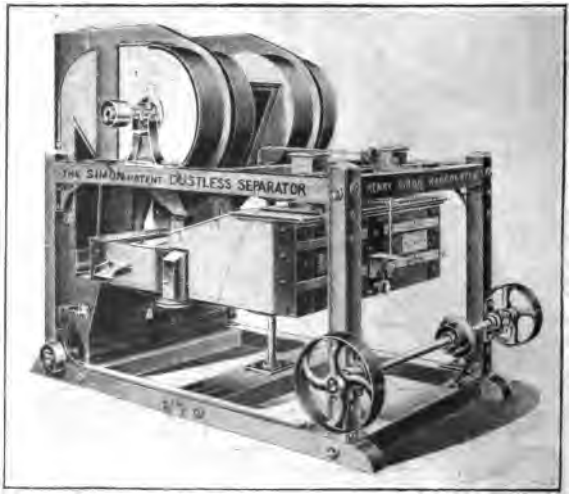

FIG. 38.—SIMON WHEAT SEPARATOR.

over them and tails away at the lower end of the cylinder. The cockle and other small black seeds (and often small broken grain), fall into the indents at some point along the line, and are carried right up until the indents are inverted, and releasing all their contents, discharge them into the centre of the cylinder. Instead of mingling with the wheat again, however, they are caught in a broad, adjustable, sheet-iron trough, slung from the centre fixed spindle, and conveyed to the delivery by the worm conveyor working in the trough.

The cylinders revolve on a fixed spindle and are driven by small belts passing round the centre of the barrel, or by special bevel and spur gears working in the head of the cylinder. In large cleaning plants a collection of these is used, contained

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in a timber frame, with a reliable system of feed distribution and discharge. The ends should be closed and each one thoroughly aspirated. Fig. 40 is an excellent example of

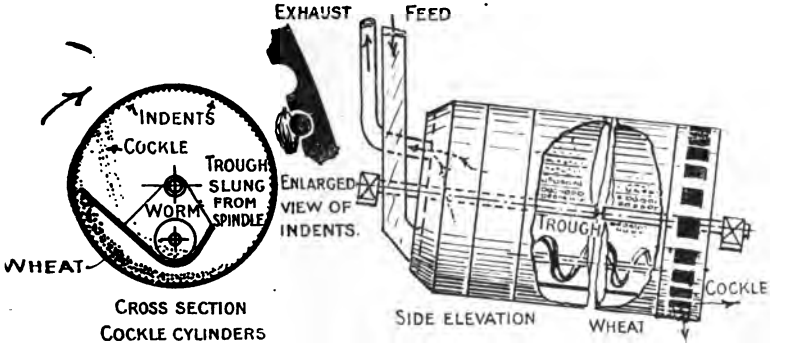

FIG. 39.—COCKLE CYLINDERS—ACTION.

this type of installation. The main counter-shaft runs at 60 revolutions. A set of 16 takes approximately 1 H.P. In these sets the top are usually barley, and the bottom cockle,

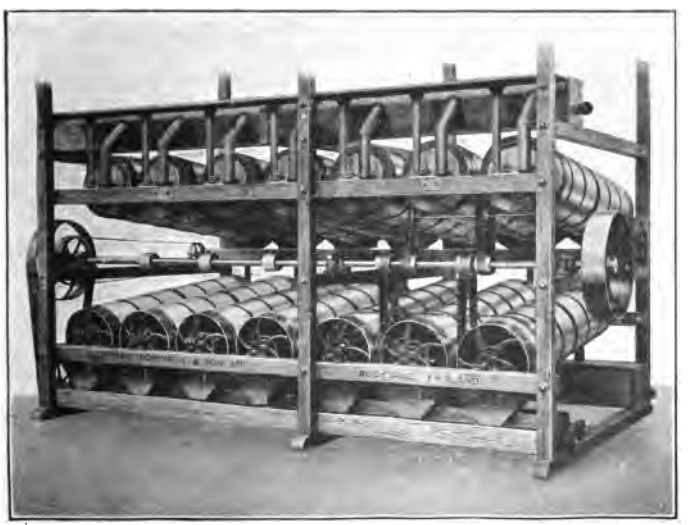

FIG. 40.—ROBINSON'S BARLEY AND COCKLE CYLINDERS.

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cylinders, the wheat passing from one to the other. The action of the barley and rye cylinders is similar to that of the cockle, except that the wheat, being the smaller, is caught, whilst the barley and rye tails over. The indents are of course larger also to suit the special needs. Many sizes of both cockle and barley indents are made to suit all classes of wheat. The incline is 1 inch per foot, and although the speeds of the cylinders vary from 6 to 15 revolutions per minute with the size, yet it will be found that the periphery speed remains at approximately 1 foot per second.

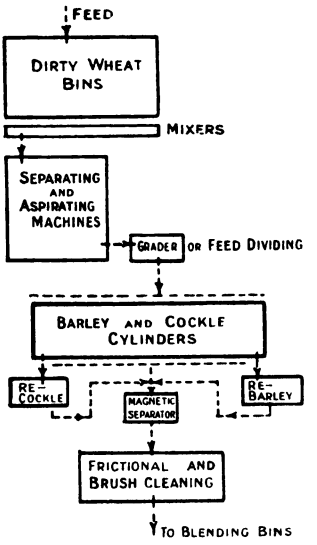

FIG. 41.—BLOCK FLOW DRY-CLEANING.

Cockle indents range from 3 mm. to 5½ mm. in diameter ($\frac{1}{8}$" to $\frac{3}{16}$"), with the class of feed. It is usual to re-treat all the seeds extracted on the main range of cylinders. These latter, dealing with large masses of wheat, must be provided with the larger indents to ensure a thorough removal of the foreign seeds. Once these are placed aside from the wheat stream they can be more exactly and searchingly treated upon special re-treat cylinders with smaller indents. A reference to flow-sheet, Figs. 41 and 42, will make this matter clear. Barley cylinder indents range from 7 mm. to 10 mm. in diameter ($\frac{1}{4}$" to $\frac{3}{8}$"), also changing to suit the class and condition of feed. Flow-sheet Fig. 42A gives an alternate method of barley and cockle extraction upon cylinders. A large rotary grader makes a good preliminary division of the wheat feed. The group containing cockle does not contain barley, and *vice versâ*, thus obviating the necessity for treatment upon both barley and cockle cylinders in succession. Feed dividers are a necessity where even feeding is desired. Some millers wash their wheats before treating at this point, and claim better

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extraction by reason of the increase in the size of the wheat as compared with the cockle. Sometimes cylinders are

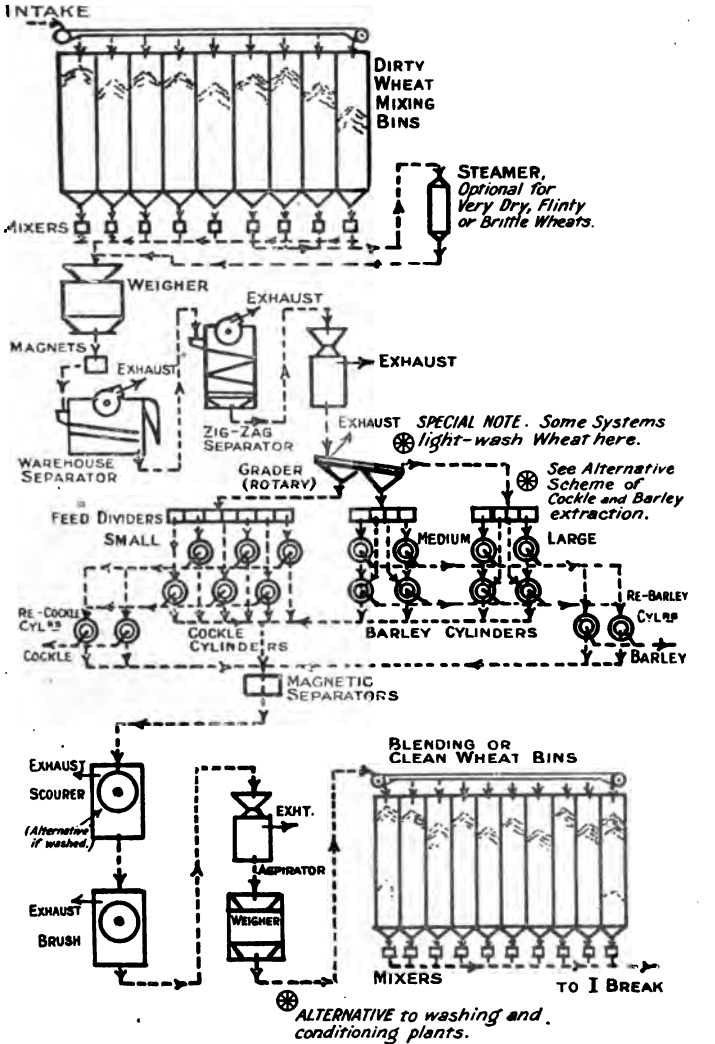

FIG. 42.—DRY-CLEANING FLOW-SHEET—200-250 BUSHELS PER HOUR.

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provided with a cockle " sieve," at the head, extending down one-third of the machine, and is reckoned by some millers to be a special benefit.

There are several other cockle extractors worthy of note, taking a line of development which may be followed up closely in the future. One, the "Record" machine, by Messrs. Simon, consists of an inclined endless band made of indented plates working over head and tail drums. The frame carrying the band is hung on springs and oscillates laterally, at the same time as the band travels lengthwise, moving up the incline. The plates are made of hardened bronze and can be easily renewed. The indents are drilled. The grain feeds on to the upper end of the inclined band from hopper and tails over at the bottom end, whilst the cockle falls into the indents and is carried up over the top drum and deposited into the hopper-mouthed spout.

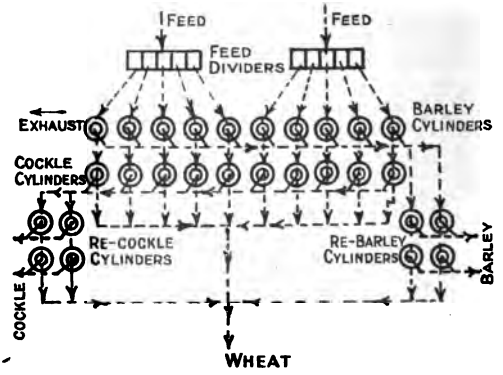

FIG. 42A.—FLOW-SHEET—ALTERNATIVE BARLEY AND COCKLE CYLINDERS.

Frictional Cleaners.—Classing these in order of severity, we have, first, the horizontal scourer with steel beater—bars only; next the horizontal combined brush and scourer, containing steel beaters and bristle brushes placed alternately; then the horizontal brush; and, last, the vertical brush. It is well to bear these points in mind, because millers have discovered that continual friction always means something going to exhaust. When the dust has been eliminated, the bran coats, in fine particles, take its place—*ad infinitum*—until a serious drop is experienced in the percentage of the offals, especially the bran. To a certain extent, aspirators have taken the place of these cleaners. Good modern practice is therefore to scour and brush once in the system, and then to aspirate only for the rest of the treatment before the blending

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bins. Polishing is the last essential before reaching the first break, and this the vertical brush can justly claim to do. Chemical changes are always taking place on the wheat skins, and it is necessary to smooth or polish off the final shreddings of the bran coats immediately before the breaks, in order that the break flour shall not be contaminated.

Horizontal Scourers and Cleaners.—Some millers refuse to scour the wheat until it has been toughened by washing, in the case of brittle wheats especially, but hard and flinty varieties will safely stand the treatment. Dried mud and adhering dirt can be removed very efficiently. Scouring also removes the beard of the wheat and any dark tissue likely to contaminate the grist. It will break up smut balls and similar impurities in the wheat. Here again much difference of opinion exists as to the benefit of this latter operation; some contend that the smut and such impurities should be kept as whole as possible until the washer is reached, when they can be safely floated away in the whole state, avoiding any smearing of the grain surfaces and contamination of the beaters, cases, and also of the following brushes. If washed previous to scouring the danger is thus avoided. Others hold that the powerful aspiration applied constantly during the operation obviates any such risk. It is largely a matter of personal judgment and the types of wheat being treated. The various makes embody the same principle of construction —*i.e.* a strong perforated case containing steel beater bars or other scouring agencies.

The case is conical, and either fixed or slowly revolving. This is boxed in an air-tight chamber, with large inspection doors at either side. Contained within this, and operating at feed inlet, through entire length of perforated scourer case, and at wheat delivery, is a large fan. The case is made either of cast-iron slotted, sheet-steel slotted, emery, or woven steel wire. Each have their special advantages. The case is usually made in segments, so that any section can be replaced quickly and removed with ease. Although the steel beaters are usually slightly spiral, to assist the travel of the wheat, and to give the grain a glancing blow, the case is made to taper, to further assist this action. The powerful aspiration, applied from the outside, pulling through all the released impurities and assisting to keep the grains up to the inner face of the case, allows the heaviest of the dust extracted to be deposited in the hopper beneath and delivers only the lightest dust to the

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collectors. The light screenings such as chaff, hollow seeds, and small straws, etc., are deposited in the screenings tips, and bagged up from these. In some cases, a shaking shoe or screen is placed above the scourer, and removes the odd rubble still remaining in the wheat mixture. These machines aim at the friction of grain upon grain as well as of the friction between beater and case surfaces. Emery casing is probably the favourite with the most progressive millers. It is durable, and can be made with surfaces in various degrees of roughness. Fig. 43 is of the scourer by Messrs. Robinson. It will be noticed that the beaters revolve inside a parallel emery

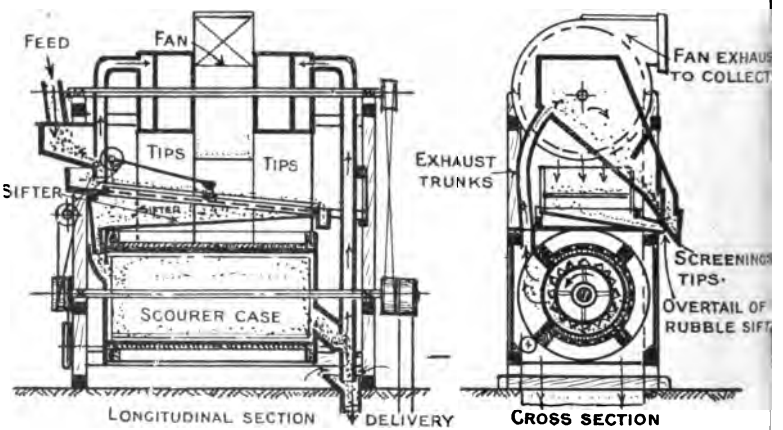

FIG. 43.—ROBINSON'S EMERY WHEAT SCOURER.

casing, and can be adjusted to permit either more or less severe scouring. The horizontal brush is a similar machine to the scourer, with the exception that the beaters are replaced by brushes of bristle. There is also a machine which embodies both actions, having steel beaters and bristle brushes, placed alternately. Scourers and brushes consume the most power per sack capacity of any machine in the dry-cleaning plant; the smallest size takes approximately 1½ H.P. and the largest 8 to 10 H.P.

Vertical Brushes.—Vertical brushes have peculiar advantages for some classes of work. The action is gentler on the wheat than in the case of the horizontal brush, the friction being applied to the wheat grains by two brushes working

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together instead of a brush against a metal case. Therefore the vertical brush is most suitable as a final polishing medium when the wheat has been well scoured and brushed of its real dirt. Fig. 44 will explain the main principles of working and construction. The wheat, feeding into the top of the machine, zigzags down, passing *en route* between brushes, instead of between brushes and case. These are arranged in pairs set at an incline toward the vertical spindle. The upper brushes are fixed to the vertical outer case, and the bottom brushes are attached to the spindle, revolving with it. Centrifugal force, and the action of these latter brushes, carry the wheat up and over the outer edge of them. The wheat gravitates to the next set of brushes. At each of these turning points, at the feed and delivery, the self-contained fan applies aspiration and lifts away light beeswing, dust, and other impurities directly liberated, depositing them as usual into a screenings tip.

The Wheat Aspirator.—This is the outcome of the increasing application of air currents in cleaning. By flinging the wheat round the whole circumference of a rapidly revolving disc, a fine spray of grains is obtained, which gives the fan the best possible chance of extracting light impurities. This principle is embodied in the aspirator. The various classes of wheat in different conditions give varying impinging properties, and these can be allowed for by the adjustable feed spout, see Fig. 45. The stock lifted away is deposited in the screenings tip. The wheat falls away to the bottom hopper. The whole action can be clearly seen by studying diagram. For removing any light beeswing or dust just before the blending bins or the first break rolls, this machine is of great use.

Fans.—The majority of dry-cleaning machines are fitted with self-contained fans, but some have to be aspirated by separately installed fans placed between machine and collector.

The Sturtevant Fan Co. make a great variety of these, and details can be readily obtained on application.

Before commencing to deal with the flow sheets of large dry-cleaning and washing plants, it is necessary to clearly understand the proportion which these must bear, in capacity, to the mill output. It has been the practice generally, until quite recently, to make the wheat-cleaning plant large enough to do the work, at well over twice the requirements of the

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mill. Thus, working 12 hours only, and using one shift o operatives, the following particulars would be worked to.

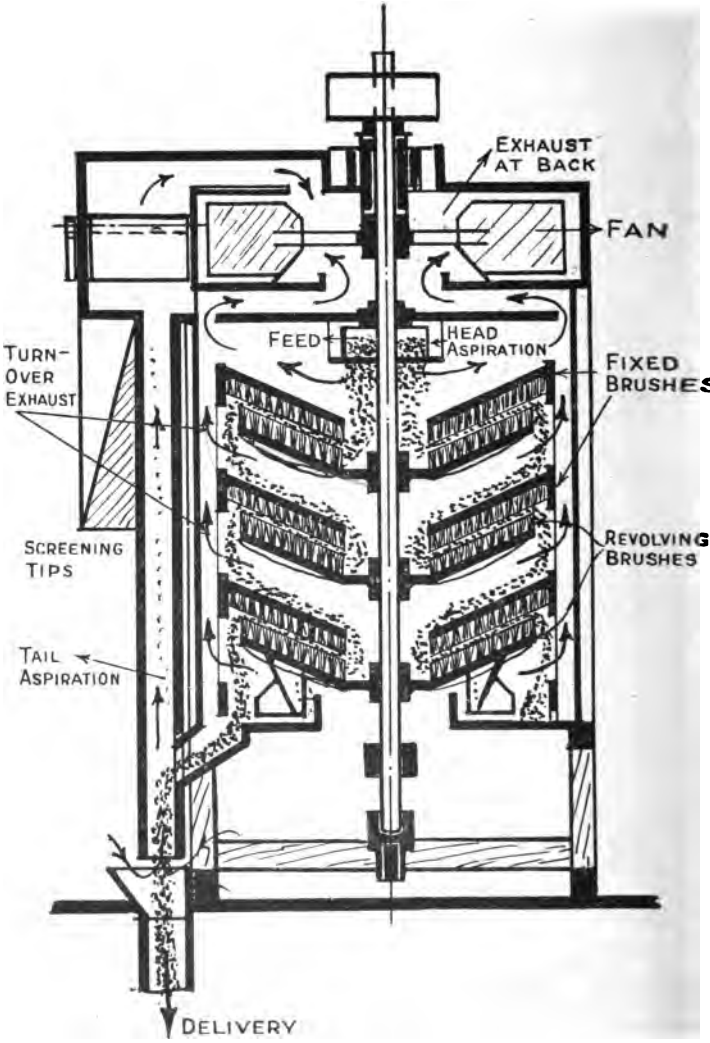

FIG. 44.—VICTOR VERTICAL BRUSH.

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Assuming that we are supplying a 30-sack plant. The total output of flour will be per 24 hours $\frac{30 \times 24 \times 280}{1}$ lbs. But this only equals 70 per cent. approximately of the wheat ground. Therefore total wheat delivered from the cleaned wheat bins equals $\frac{30 \times 24 \times 280 \times 100}{70 \times 60} = 4800$ bushels of wheat (at 60 lbs. per bushel). But this is clean wheat with approximately 5 per cent. of impurities removed. Therefore the dirty wheat must be 4800 bushels + 5 per cent. = 4800 + 240 = 5040 bushels. There are other factors to be considered. The wheat, assuming washing, has received 3–4 per cent. of added moisture, but against this is the fact that plants of this description are apt, under the worst conditions, to choke, and allowance must be made for this fact. Therefore the final figure of *receiving* wheat capacity may be taken as approximately 10 per cent. in excess the mill's requirements of wheat + the 5 per cent. for screenings extracted. This equals 4800 + 15 per cent. = 5520. This is the total output for each day of 24 hours. Working 12 hours only the plant must have an hourly receiving capacity of $\frac{5520}{12} = 460$ bushels. Now this is obviously too big and unwieldy for one plant working efficiently and to the best advantage. Therefore it can best be divided into two plants of 230 bushels each. We can now deal with one of these, assuming that they are similar and can work separately on special wheats or mixtures, or in unison on a divided wheat mixture.

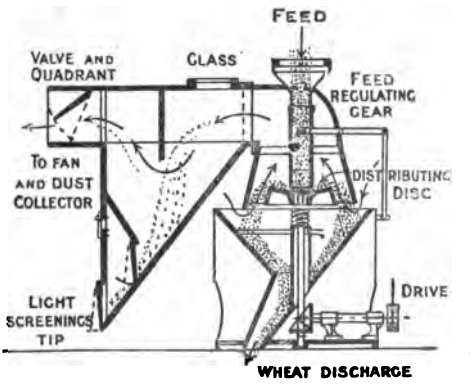

FIG. 45.—ROBINSON'S WHEAT ASPIRATOR.

There is a change in attitude now, and millers are disposed, in many cases, to work the cleaning plant or plants almost

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continuously, especially for very large mills. This reduces its size and increases the labour bill.

Cleaning Plants—Dry Process.—In arranging the dry-cleaning plant (in the building), the scheme in Fig. 46 has

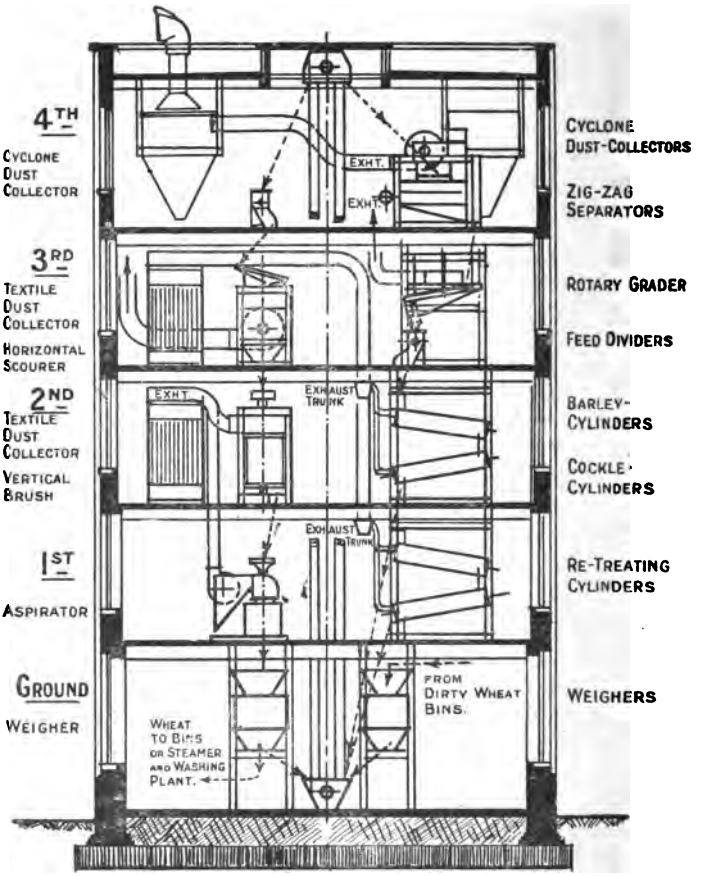

FIG. 46.—CROSS-SECTION DRY-CLEANING PLANT.

points of advantage. Keeping the weighers on the ground floor will be a means of steady fixing and more efficient weighing results. The apparatus recording feeds to and

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deliveries from the cleaning-plant can both be placed here. The wheat can be elevated to the top floor and deliver to the first cleaning machine as shown, and zigzag down through the grader, cylinders, scourers, brushes, and aspirators, following down the building, and finally elevating to the steamer or damper above the washers. For the sake of clearness, the storage and soaking bins have not been shown. If a sufficient number of floors are not available, then the wheat must be elevated to suit. With several plants in one building it is advisable to group each set of machines separately, although sufficiently in touch to enable interchanging in case of emergencies. The blending and grinding bins, and the final polishing plant, should be kept to themselves as much as possible to avoid contamination. The dust-collecting apparatus, a most important section, is best isolated, whether the cyclonic or the tubular textile types are used. Cleanliness in all parts of these buildings must be maintained.

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CHAPTER XIII

WHEAT WASHING AND WHIZZING

WATER judiciously applied is the most profitable method of treating wheat in cleaning and conditioning. It can be used to wash the softest, smutted, and damp grains by a rapid process, to advantage; to wash harsh, dirty wheats by a slow process, with many turnings and rinsings; to wash hard, dry brittle grain to the best advantage of all. It is used as a separating agency, by weighing, as it will deposit heavy impurities, such as stones, flints, clay balls, and heavy seeds, and will float over light weevilled grains, smutted grains, seeds, husks, etc., which may have escaped the previous dry-cleaning machines. It will add the required amount of water to the very dry wheats by becoming incorporated in the skins to a slight but sufficient degree. It renders harsh-skinned wheats milder; brittle, friable skins tougher; and hard, horny skins softer. To a certain degree it adds weight to the miller's flour and offals.

A section of the milling industry advocate and practice the use of washing alone, as a means of lining up the various wheats. In order to render this effective, it is necessary to: (1) "Wash" certain wheats two or three times; (2) to run certain wheats through a stream of water with the minimum of soaking; and (3) to rinse or sprinkle certain clean, soft varieties. See flow-sheets, Figs. 47, 48.

Taking case (1), one method is to wash, whizz, and empty into a special bin for some hours, all brittle, dry or harsh wheats, sending them to the mixture either for complete treatment through all the dry-cleaning and washing plant, or direct to the washing plant. In this latter case it will be necessary to give the wheats a good dry-cleaning prior to the first washing. An alternative in case (1) is to damp these wheats in a worm before mixing in for dry-cleaning. There is a risk of plastering dust and other impurities over the wheat surfaces. Another way is to dry-clean the two broad classes

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separately and mix in at the washer, running all the harsh, hard and brittle wheats through all the soaking, turning, seething, and rinsing mediums, and the soft to medium wheats through the floating and rinsing section only. In this way, although the complete mixture is whizzed and conditioned together, yet one section has received a much more severe treatment than the other, and the whole should give a fairly even condition. Some millers, again, treat the dirtiest, harshest, and most brittle wheats through a complete separate dry-cleaning, washing and whizzing plant. They clean and wash the remaining wheats of the mixture also separately, and then run the first section in with the latter at the washer.

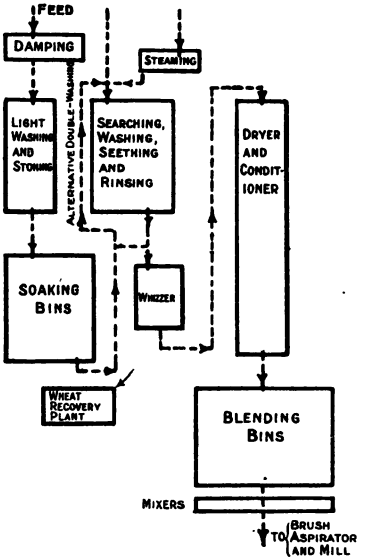

FIG. 47.—BLOCK FLOW—WASHING AND CONDITIONING.

Taking case (2), to dry-clean the entire mixture together, with the exception of the softest, weakest wheats, treating the latter to a light washing on a floater and stoner, and the former on a complete washing plant. Then to whizz and to condition together.

Taking case (3), to wash together all but certain very soft clean wheats, containing a natural excess of moisture, and to run these in with the mixture, at the last moment, as it enters the rinsing-worm feeding the whizzer. There are other alternatives, but the main ones have been dealt with. The principle underlying these methods of washing is that the surfaces of the different wheats have a widely differing absorbing capacity. All common thin wheats are fibrous and open and absorb and retain water. Hard, lustrous, and sound grains retain less moisture on their surfaces and absorb less into structure. As a guide in this matter the main wheats absorbing water most quickly are Common Azima and Ghirka, low-grade Plates and Americans, both Spring and Winter, Soft

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English and Baltics. Hard and flinty wheats give trouble because they absorb water so slowly. These will be Hard

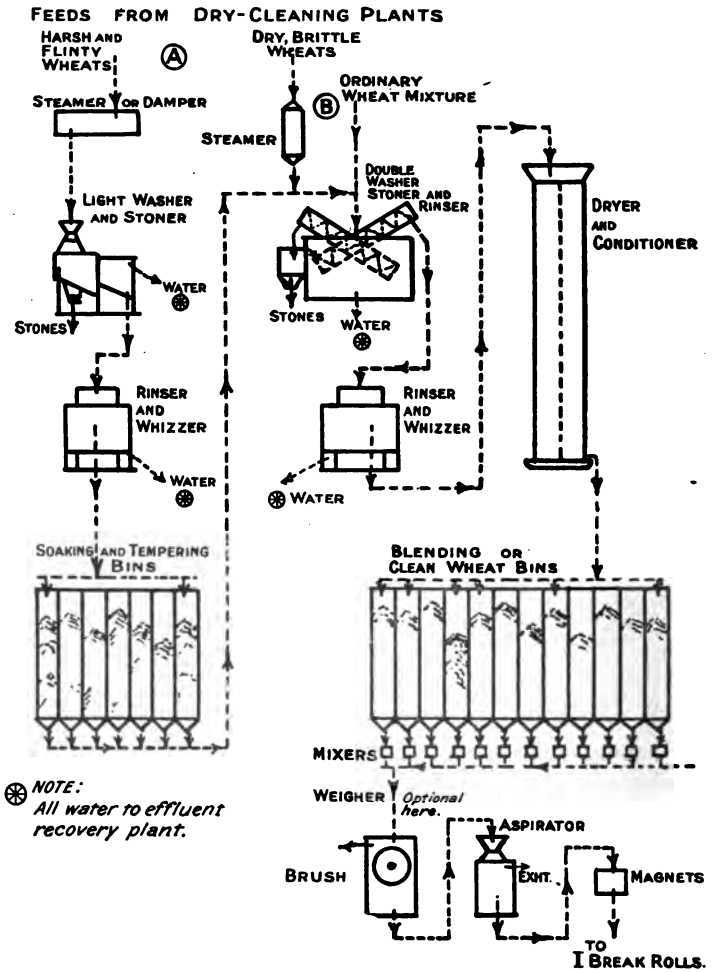

FIG. 48.—FLOW-SHEET—250 BUSHELS—WASHING AND CONDITIONING PLANT.

Plates, Indians, Danubians, Persians and Kansas, also Taganrog and Kubanka Cones. The happy medium in the matter of

absorption is struck in Duluth and Northern Spring, Good English, Good Plates, Canadians and some Western Americans.

The amount of water used in washing is an uncertain quantity, differing with the class of wheats used, the aims of the miller as to the resultant moisture percentage, the nature of the water (which, if hard, or lime-impregnated, will not penetrate the wheat skins like soft rain-water), the system of water circulation, and the percentage running to waste, the average amount of rinsing water, and the amount absorbed and driven off in the dryer. These, and other considerations, all affect the water consumption. In the " return " system, the supply of fresh water from the pumps or the main varies from 2 to 4 gallons per bushel per hour. When used once only, the quantity used varies from 15 to 22 gallons per bushel per hour. The 10 to 15 per cent. of added water present in the wheat as it enters the conditioner, is reduced to about 2 to 5 per cent. as it leaves the machine.

Chalky (lime impregnated) waters tend to coat the wheat and render it impervious to the softening action of the water. Hot-well condenser water is dangerous to use unless run through open trough to cool, and roughly filtered. The ideal is probably rain-water. It is not a really good plan to use water several times over (although this is about the only course open to the miller with a scanty and costly supply available). It tends to leave the wheat surcharged with slushy mud and sediment. The use of water makes it possible to temper and " line-up " the wide range of wheats with which the English miller has to deal. If wheat is soaked too deeply with water the whizzer will shed the extraneous moisture only and send it on to the conditioner in a state which will spoil future work. On the other hand, the bulk of wheat may be very hard, and refuse to absorb even a small amount of water. The trouble is then that the whizzer will probably fling off practically all the water because it is present only on the outer surface of the wheat. This naturally prevents much heat being employed in the conditioner. The problem then is, how can the hard wheats of the mixture be made to absorb water while immersed in it for the comparatively short time required for the softer wheats ? In the old days this was met by damping Russian and Indian wheats, etc., before mixing with the other and softer varieties. Now the method in favour is that of steaming. This really amounts to opening the pores of the wheat skins, and slightly tempering them

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by passing them through a steaming machine. Then, run through the dry-cleaning plant with the other machines, the wheat is more sensitive to the penetrating action of the water.

The following descriptions are of those machines, and are on the lines of the systems most favoured by the English miller.

Double Wheat Washer and Stoner (Robinson), see Fig. 49.—Wheat is fed into stoning vat at bottom end of first worm. Vat is fitted with two adjustable valve-discs to vary water for stoning operation. The 18-inch diameter first worm sucks

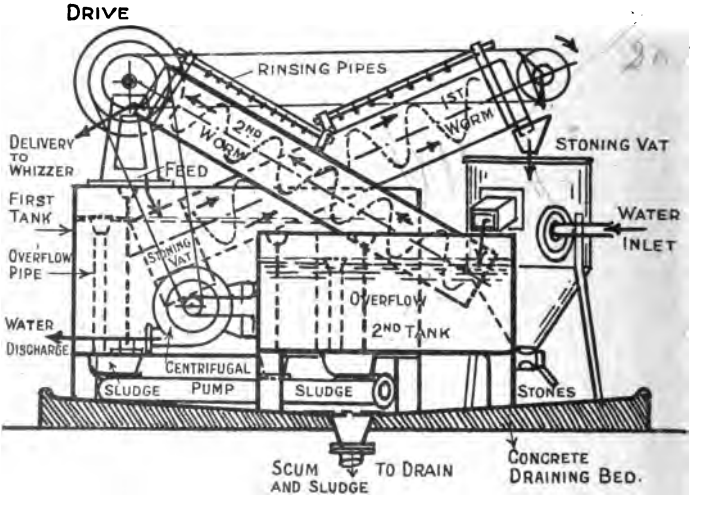

FIG. 49.—ROBINSON'S WASHER.

water and wheat through valve openings, leaving some of the stones behind. Wheat conveyed to upper end of worm falls into stoning vat (this vat is somewhat like the Turner Stoner), and wheat, carried by overflow of water, falls into 12-inch diameter second worm, is conveyed to top end, and thence to whizzer. Cases of both worms are either of brass or copper to avoid corrosion. Both worm casings are perforated in order to drain away the bulk of water. Both worms are provided with rinsing pipes and nozzles, which deliver jets of water on to the turning mass of wheat. The used water falls into special division in tank, and is withdrawn by the centrifugal pump and delivered to tank overhead. The overflow of this

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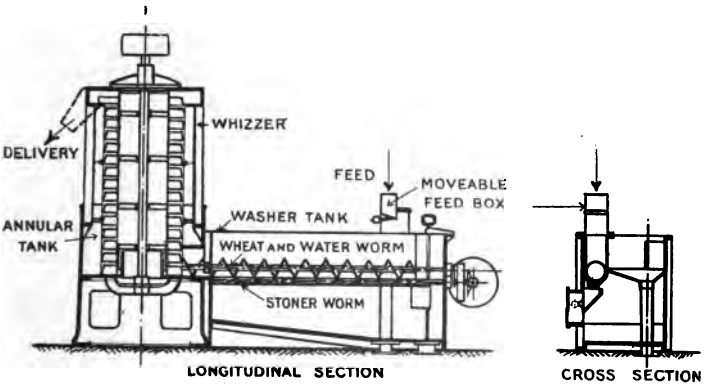
tank is connected to first stoning tank, whilst the bottom is connected to stoning vat through regulating valve. Mud valves are fitted to bottom of tanks, and overflow of both tanks to drains or recovery plant. The whole installation is fitted on a concrete draining bed.

The Simon washer contains an eccentric-driven pulsator sieve, very useful when treating wheats containing clay and earthy matter. The usual inclined rinsing and draining worm is included.

Simon's "Reform" Combined Washer, Stoner, and Whizzer (Mumford patent), Fig. 50.—It consists of a washing and stoning tank with worms in combination with the "Simon"



SIMON'S REFORM COMBINED WASHER, STONER AND WHIZZER.

FIG. 50.

ventilated vertical whizzer. The tank contains a trough, and the two worms revolve in this one above the other, and in opposite directions. The large top one conveys the washed wheat to the whizzer, and the bottom small one removes the stones deposited from above, and discharges them into a retaining box from whence they can be removed periodically. The wheat is fed into the worm trough by means of a special feed box, fitted in such a way to the top of the trough that it can be moved along, feeding the wheat into worm at any point desired, thus varying the time of immersion before discharge to the whizzer, a valuable feature in the case of very damp wheats, requiring washing. The circulation of the later is effected by the propelling action of the wheat worm

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alone, pumps being dispensed with. As Fig. 50 indicates, the whizzer is provided with an outer annular cover or tank. This receives the water discharged from the wheat and returns it to the washing tank to be re-used. An amount of fresh water is run into the tank, the proportion varying, of course, with the nature of the wheat under treatment, and the amount of scum and dirty water it is found desirable to overflow. The overflow pipe is fixed in the main washing tank, and can be moved to give a variable level of water in the washing worm. The whole operation of washing and stoning is open to view. The amount of stoning, the regularity of working, the state of the water, etc., can all be seen.

When used as a separating agency mainly, the floater or stoner type of washer is most useful. A good example is the Turner Concentric Washer, Fig. 51. Wheat is fed on to the top of the brass cone and pours in a thin even stream all round its circumference. As it reaches the base of the cone, it is met by a steady uprising stream of water, which can be so adjusted by a wheel valve that the wheat is lifted over into the first tank and the stones and sand only will sink into the stoning cone. The lightest wheat, accompanied by all light impurities, will float into the outer tank and allow of a further deposit of grains, which will join the heavy wheat at the delivery spout. Smutted, immature, and hollow grains, light impurities and chaff and some garlic (in wheats containing this nuisance) will float away into overflow spout and perforated scum tank.

Apart from washing away clinging dirt, stoning is an important feature of immersion in water. Stones, whether of the heavy-quartz type, present amongst Chilians, or of the light porous nature of those amongst Russians, must be removed effectively. Carefully worked, water is the best separating and weighing agency in use.

Wheat Whizzing.—Having now soaked, washed, cleaned and rinsed our wheats, the surplus extraneous and absorbed water must be removed as quickly as possible in order that the strength of the wheat is not impaired. Three means can be employed, *i.e.* centrifugal force, air currents, and heat. The first and the last must be used with caution. To deal with the first—whizzing. It consists of pouring the wet wheat into a vertical perforated cylinder and threshing it round and up by rapidly revolving beaters (at about 3000 feet per minute).

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Centrifugal force holds the wheat close up to the inner face of the cover, and the water is flung off, and drains away. The wheat, reaching the top of the case, falls out and goes to the dryer. The principal danger to the grain being treated is that of abrasion. The scouring action cannot altogether be avoided and the wheat is in the worst possible state to safely

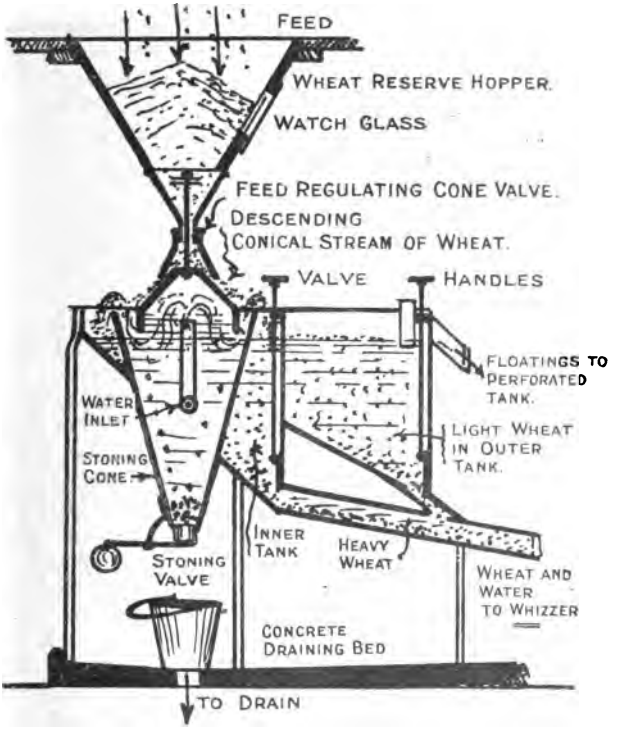

FIG. 51.—TURNER WASHER.

withstand this, being wet and soft. The bran-coats flake away rapidly, and soon form a plaster of bran mash which is worked through the case, sometimes to ¼ inch thick. If any really effective work is to be done under these conditions, constant removal of this mash must be effected. Some millers instal a rinsing pipe encircling the whizzer, a constant spray from which clears the case perforations. Others provide a long

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fine ½-inch flexible armoured hose pipe, with a heavy water pressure. With this the operative cleans down as often as necessary. Many improvements in whizzers have taken place recently, the most notable, perhaps, being the induced draught through the cover as a further help to clear the perforations, Messrs. Simon making a cover with tangential perforations, arranged so as to be exactly concentric with revolving barrel and lifters. All these points aim at reduction of friction, clogging, and smashing of the grain.

The most perfect machine does not dry the wheat, nor does it seek to do so. It merely receives the wheat, either afloat in water or in a very damp state, and delivers it, damp, but free enough to be worked.

The Turner, Robinson, and Simon types of whizzers are all made with revolving beaters or lifters and fixed covers, while the Rowlandson type has revolving case and fixed lifters in both vertical and horizontal types.

Points to be watched in working.—Set lifters accurately, to avoid scouring grain, or bursting perforated case. Adjust bearings to ensure perfectly steady drive. Examine exhaust water for escaping grain, which spells a burst cover.

Rowlandson Vertical Whizzer.—Consists of two cases, the outer of cast iron, and stationary, with inlet and outlet spouts attached, the inner case of brass. This has a perforated (steel) cover attached and is fixed to a central spindle, revolving with same at about 700 revolutions per minute. Cast on this inner case are curved blades, and, being on outside of cover, set up an air suction which helps to draw out sludge and water. Wheat and water coming direct from washer are fed into spout cast on top cover. The feed pours through centre of machine, zigzagging from revolving discs on central spindle to fixed circular shelves. When it touches the coned bottom of the inner case it immediately spreads by reason of the centrifugal force and bears hard against the bottom edge of perforated cover. The lifting action is obtained by two vertical c.i. lifters, bolted to the top cover. These are best described as small segments of a cylinder with a deep screw thread on the outside. The lifters are set so that the edges of thread are within ¾ inch of cover. The wheat revolves so rapidly and catches these thread segments so frequently that they have the effect of a continuous screw, that is, they lift the wheat from bottom to top of inner case, only very slowly compared with a continuous screw. This enables the wheat

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to fling off moisture and sludge before it lifts over the top flange of case into outer delivery spout, and thence to conditioner. A rinsing pipe, spraying water into rinsing chamber (see Fig. 52) helps to keep grain free from sludge.

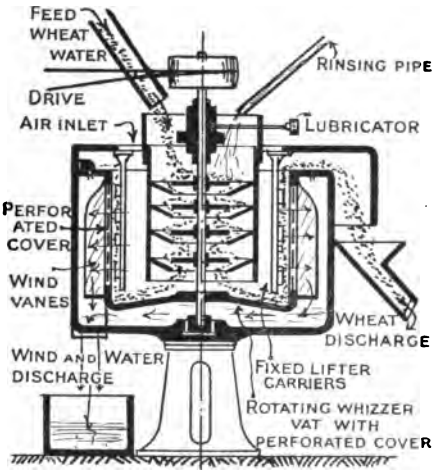

FIG. 52.—ROWLANDSON'S VERTICAL WHEAT WHIZZER.

The Horizontal Whizzer. — This machine has no central rinsing chamber, but the wheat and water are flung direct to the inner face of perforated cover by dished plate. It travels horizontally along the case aided by fixed carriers (or screw segments) as in the vertical machine. The aspiration is supplied by four outer wing blades cast on outer circumference of case.

Perforations, steel cover, 10 per inch, hexagonal in shape.

Fig. 53 gives a representative type of vertical whizzer.

Effluent Recovery Plants.—In large washing plants every item rapidly assumes large proportions, and matters which in a small plant can be safely neglected, must in the former case be carefully dealt with to avoid waste and loss of money. One source of annoyance and loss has been making itself felt in the waste water from the washing system. Sudden, and at times unavoidable, bursts in the whizzer covers, an excess of brittle-skinned wheats in the mixture, resulting in a good deal of bran mash forming on the whizzer cover surfaces and necessitating frequent washing-down, lifter-bars set out of truth or too close—all these spell escaping bran mash and broken grains amongst the water discharged to drain. Even in the most efficiently operated plants some such loss is bound to occur. Although provided with straining grids the outfall to the sewers will still contain a percentage, which soon

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accumulates sufficiently to make itself felt and to provide a grievance for the local sanitary authorities which they are not usually slow to air.

Their contention is, of course, that the grain will lodge at various inaccessible places, and, starting growth, will choke the sewers. Besides this, the miller has always before him the fact that material for which he has paid is being lost. To obviate this trouble, the effluent recovery plant has been designed. From amongst the makes now in use and on the market we will examine two well-tried types. Fig. 54 gives the "Simon" plant. It consists of a receiving tank, an inclined water strainer, a beeswing press and a dryer, all working in combination. The whole of the water from the washer and whizzer troughs feeds into the receiving tank, and from thence pours across a specially clothed sieve or water strainer, on which all the beeswing is separated from the water. Automatic brush-sweeps keep the mesh clear, and collect the mash, feeding it into a continuously running press. Here the majority of the water is squeezed away, and the material is delivered in a fairly free state to a steam-heated dryer, from which it issues quite loose and free, without any tendency to cake or choke in the delivery spout. It is then either sacked off or mixed in with the offals, or other stock as desired.

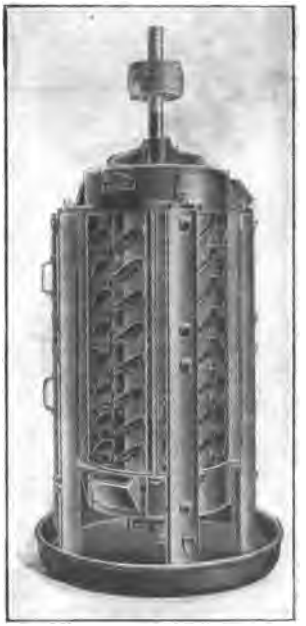

FIG. 53.—BRITANNIA VERTICAL WHIZZER.

A recovery plant by Messrs. Amme, Giesecke & Konegen is also in use in a number of mills.

Cleaning Plants.—In arranging wheat-cleaning plants, several points must be carefully borne in mind. First, it is safer and easier to elevate or convey grain in the dry state

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than in a wet or even a damp condition. Therefore it is obviously better to place the washing and whizzing plant on the top floor, and the dryer and conditioner immediately beneath them. In such a scheme, no elevator will be needed for the wet wheat, and the waste water, whether run through an effluent-recovery plant or direct to sewer, can be more efficiently dealt with. It is possible to obtain a clean fall and

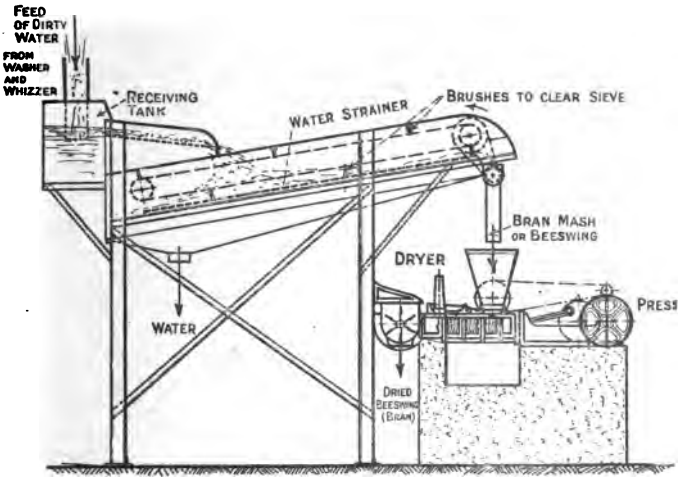

FIG. 54.—SIMON'S EFFLUENT RECOVERY PLANT.

avoid pumping, see Fig. 55. The main supply tank, either on the roof or the top floor, will be fed by a pump from the source of supply, and can fill the "return" tank immediately beneath it. This will in turn deliver to the washers, giving sufficient pressure by reason of the head alone. The washing plant pump will return the used water to this tank. The scum will overflow, either to drain direct, or *via* effluent-recovery plant, and the remainder of fairly clean water will be diluted with clean water as already pointed out. The washer floor must either be of concrete with the section round the plant set to falls, or a special concrete draining-bed must be constructed. The dirty water or scum can be easily run away to almost any desired position with such a fall at disposal. If the height of the building, and the depth of the conditioner allows it, the washing plant could be placed on the lower

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floor, leaving the top floor and roof for the storage and return tanks, as shown. The whizzer, feeding direct to the conditioner, will thus obviate the necessity for a damp wheat elevator.

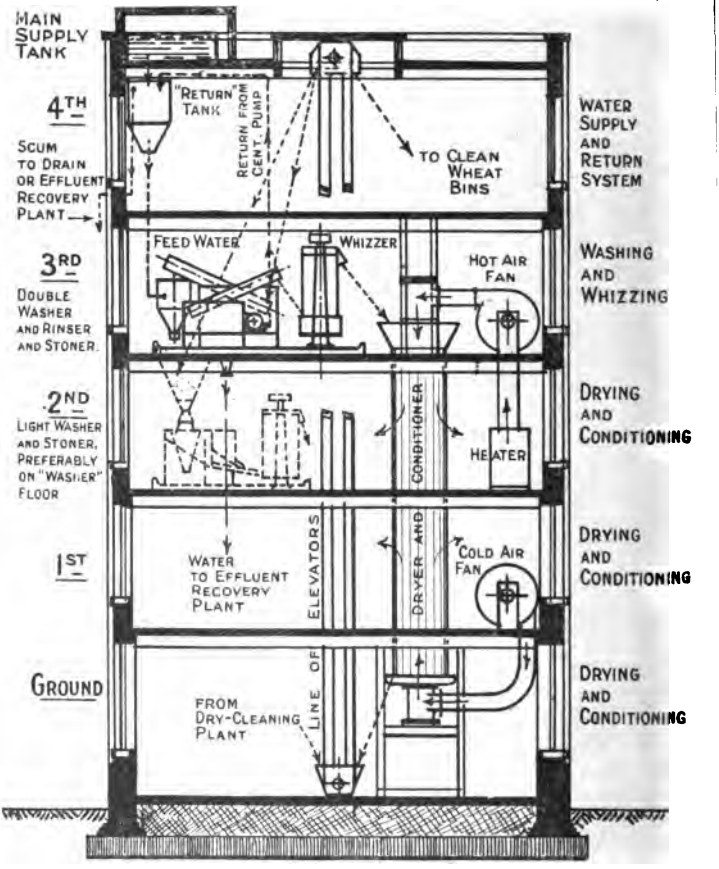

FIG. 55.—CROSS-SECTION WASHING AND CONDITIONING PLANT.

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CHAPTER XIV

WHEAT DRYING AND CONDITIONING

THE application of moisture and heat to grain has a special value, within certain bounds. It must be borne in mind that the increased percentage of moisture in grain and the heat treatment alter the chemical structure. The delicate organs of germination are encouraged to start operations, only to be arrested after proceeding a short time. The work accomplished we call fermentation. It has been caused by the birth and death of myriads of minute organisms or bacteria, brought into being by the awakened germ. In the brief period of their existence they cause a rise in the internal temperature of the grain, and for their food they depend upon a certain amount of created sugar (*i.e.* sugar converted from the starch). This stage is termed the primary fermentation. In a day or so, the bacteria die for want of this food and are immediately followed by bacteria creating and feeding upon acids. This stage is termed the secondary, or final fermentation. In the first stage the grain is sweet to the taste, and in the second stage is sour. Both these operations may be slight or severe. In most washing and conditioning plants they are but slight. It is therefore very necessary to grind the wheat whilst in the first "ferment," so as to obtain the benefits of a good sweet flour and tasty loaf, without any real loss of strength. The grain must never be left until the sour stage is reached. This accounts largely for the usual practice of 24 to 48 hours' storage only in the blending bins. The mere loss of moisture percentage is but a part of the reason of restricted storage of "conditioned" grain.

Moisture testing as a means of determining the state of wheat in either the natural or the conditioned state is quite an established feature of the flour mill. It is necessary that the method of testing should be scientific and exact. In testing raw wheat for the percentage of moisture the results obtained should govern the treatment of that wheat. The difference

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of one or two per cent. will materially alter the treatment and the cost of preparation for milling. In testing conditioned wheats, the object is to check the work of the previous treatment. Specific gravity was, until recently, the main approved method of testing. Extraction of the moisture is now found to be more effective. To take a typical moisture tester now in use. The apparatus shown in Fig. 56 is that made by Messrs. Thomas Robinson & Sons, under the Brown and Duvel patent. The method of working is the following. A carefully weighed quantity of wheat grains, usually 100 grams, taken impartially from the parcel of wheat under test, must be placed in the distillation flask, and well mixed with 150 cubic centimetres of oil. Insert the thermometer, carefully sealing the inlet by the rubber stopper to prevent leakage of vapour. The mercury bulb of the thermometer must be four-fifths submerged in this oil. Place the flask in its special compartment, and by means of the rubber stoppers on side tube of flask, connect it with the thimble of the glass condenser tube, extending down through the cold-water tank, so that the moisture liberated from the grain will be condensed and collected in the graduated cylinder beneath the tank. Cover the flask, ignite the gas from the burner immediately beneath the wire gauze, adjusting the flame so that it reaches the desired temperature, usually about 180° C., suiting the particular grain under test, in about twenty minutes. Then extinguish the

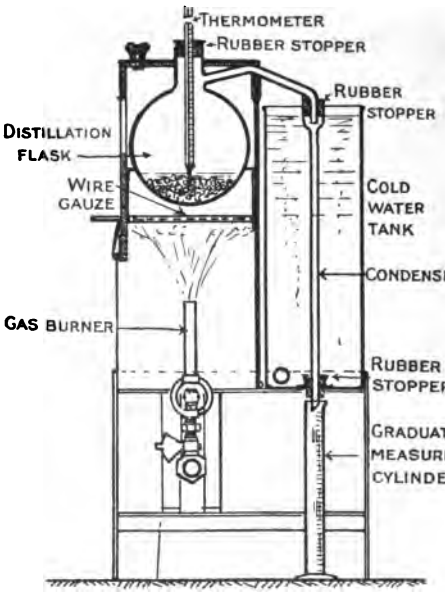

FIG. 56.—ROBINSON'S MOISTURE TESTER.

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flame immediately. The distilling vapour will drip from the tube for about five minutes, and the test is complete. Oil of fine quality, free from water, and having a flash point of from 200° to 205° C. should be used. Mineral oils, or the lightest and best class of lubricating oils, are the most suitable. The standard cylinders for measuring the moisture have a capacity of 25 cubic centimetres, and are carefully graduated in fifths, so that the reading can be readily made in tenths, all readings being made directly in per cent. unless other than 100 grains are used for the test. The distilled water should be clear. Before the test it is important to warm the flask and tubes to evaporate any dampness within. The apparatus must be used in a cool dry place. The flame must not actually touch the flask during the test.

Steaming and Damping Wheat.—Whenever in a number of wheats proposed for a cleaning mixture we come across a grain which is noticeably more brittle, dry, or harsh than the rest, we endeavour to tone it down so that it will respond to the treatment meted out to it whilst being washed, whizzed, and conditioned with the rest of the mixture. The application of water in some form is advocated as the most successful method, and the wheat is either damped, soaked, or steamed. The usual method adopted in steaming is embodied in the Fig. 57. This particular apparatus is by Messrs. Henry Simon. It consists of a jacketed steam cylinder or chamber through which the wheat showers freely. Steam pressure, with its corresponding temperature

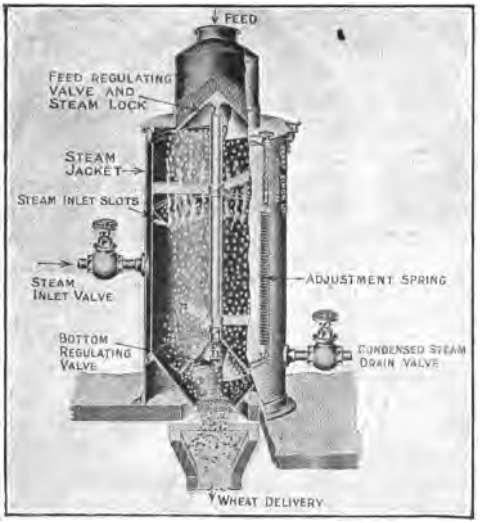

FIG. 57.—SIMON'S WHEAT STEAMER.

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and "wetness," is regulated by the inlet valve. It first enters the outer "jacket" space encircling the steamer and then flows through the inlet slots, into the inner chamber, mingling with the wheat, and adding a small percentage of warm penetrating moisture to the bran-coats or outer skins. The condensation in the jacket is drained away as shown. High pressures of steam, with corresponding dryness and heat, are unsuitable. The narrow inlet and outlet spaces through which the wheat flows prevent any appreciable leakage of the low pressures of steam employed. The feed spout is fitted with a regulating valve connected by a vertical rod to the bottom delivery valve, the two working in unison and being automatically regulated by a spring. This maintains an even and continuous flow of grain under varying amounts of feed. Other makers employ worm-conveyors encased in steam-tight boxes, through which the wheat is conveyed, whilst being subjected to the steam jet. Steaming has been found of benefit to such earthy tainted wheats as Kurrachee. If used as damp as possible ("saturated steam" is the term) it will remove this objectionable taint by freeing the pores of the wheat skins from the minute particles of dust clogging the surface.

Wheat Damping.—Another method employed for these obstinate wheats, or in some cases for soft wheats requiring a slight rinsing, is to run them through a damper, adding surface water only. Although in this case again the method often employed is that of a worm conveyor into which jets of water are sprayed, the better type is that which consists of an enclosed paddle wheel rotated by the passing stream of wheat. On this paddle spindle is fixed a water-wheel, carrying a number of small buckets. This latter revolves in a water tank fitted to the side of the paddle or "breast" wheel, and automatically supplied with water by a ball valve inlet. The water-wheel delivers its water on to the wheat passing over the paddle blades. The flow of the water is entirely governed by the wheat feed. Irregular damping is thus overcome, because should the flow of wheat increase or decrease, the revolutions of the breast wheel increase or decrease in sympathy, and more or less water is delivered to the wheat by the bucket wheel in proportion. If the wheat feed ceases, the wheels stop also, and no water is delivered.

Wheat Conditioning.—The conditioning of wneat is the process of lining up the various wheats in a mixture to the same

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degree of hardness, toughness, and mellowness, so that each individual grain shall stand the same breaking down on the rolls, with the approximate same results, in large bran flakes, small percentage of break flour, and plenty of good, bright semolina and middlings; that there shall be no bran powder (practically) (due to brittle skins and too small percentage of water), and no pasty, juicy bran, stained flour, and lost flour in the offals (due to too great a percentage of water). Conditioning also aims at ripening the grains, where such is needed. After a wet, cool harvest, the careful treatment of the crop in a conditioner will be of great benefit in removing the excessive moisture and in hardening the bran. It will also, through the agency of the gluten and the germ, improve the general ripeness of the grain. Great care must be exercised in applying the right amount of heat, the air currents, and in judging the correct length of time the grain shall take in its passage through either the hot or the cold section of the conditioner. Grain which has been saturated, whose bran coats, right to the gluten cells, are damp, will stand only a moderate heat, in order to gradually evaporate the steaming moisture and redeem the skin from sloppiness. Should the heat be excessive, above 120° F., then trouble will probably follow. The outer skins will harden, and steam forming beneath these will tend to shed the bran skins when they eventually dry and shrivel. The damp heat will also weaken the resultant flour.

It is very essential that wheat should yield to the same treatment with approximately the same results. That is, that the bran should remain consistently large and the break flour should be kept to strict limits. That all break stock should be large, free and lively, with the highest possible percentage of bright clear middlings, semolina, and dunst. The pressure of steam used in dryers varies from 5 to 40 lbs. with 10–15 lbs. as an average, in most mills. The usual system of applying this heat is by the indirect method; thus the steam, heating a chest of pipes, through which it passes, converts these into a radiator heating the air passed by the fan through the wheat. It will be obvious that a large reduction in temperature will take place between the heat of steam and the temperature of the air passed through the grain. We know that the grain suffers deterioration if heated as high as 100° F., yet steam pressures are sometimes used, of, say, 40 lbs., giving a temperature of approximately 267° F. Yet the large volume of air passing takes only about

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120° F. to 130° F. to the grain; this again, being constantly moved, will not exceed 80° F. The following table gives the main essential steam pressures and the corresponding degrees of each respectively:

PROPERTIES OF SATURATED STEAM.

Absolute pressure.	Temperature in ° F.
1 lb.	102° F.
2 ,,	126 ,,
5 ,,	162 ,,
10 ,,	193 ,,
15 ,,	213 ,,
20 ,,	228 ,,
25 ,,	240 ,,
30 ,,	250 ,,
35 ,,	260 ,,
40 ,,	267 ,,
45 ,,	274 ,,

The idea in working a conditioner is to keep the grain from massing or bunching together, by frequent opening out and turning over during its passage through the machine, so that air currents, whether hot, as in the first section of the machine, or cold, as in the second section, may have the greatest possible effect upon each individual grain. Two systems are in use in conditioners for the application of air currents, *Suction* and *Blast* (or blowing). The main lines of best modern practice are: (1) Wheat must be kept moving in a continuous thin stream, which must travel broad and unbroken, hence the feed and delivery must be automatically coupled up; (2) wheat, in the drying section, must be subjected to a continuous warm aspiration, of an adjustable temperature and strength, operated by a large and steady fan, capable of moving large volumes of air; (3) sudden rises or falls of heat are harmful and must be guarded against; (4) moderate exposures, 6 to 8 minutes, to moderate heat, 100–120° F., are safer and more effective than short exposures, 2–3 minutes, to high temperatures (say 200° F.); (5) the heating medium must be steam radiator-heated air; (6) the resultant moisture percentage is to be aimed at rather than the removal of a certain quantity of added moisture; (7) a cooling section for final setting of the grain is essential, and aspiration for this and for the previous

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heating is better by suction than by blast, being more regular and more easily controlled; (8) the air supply for both sections must be drawn from a pure, dry source; (9) the fan exhaust must be into a good collector or expansion chamber because of the, at times, large quantity of beeswing lifted away. A periodic collection of this can then be made, and the light stock mixed in with the offals; (10) the construction of the dryer or conditioner must lend itself to a thorough inspection of all parts, and must be accessible for cleaning, and free from any tendency to chokes or lodgments.

There are, broadly, two types of conditioners; one in which the grain descends in a hollow cylinder, and one in which the grain zigzags in a broad thin stream, turning over again and again and thus allowing the hot and cold air to thoroughly search the grain.

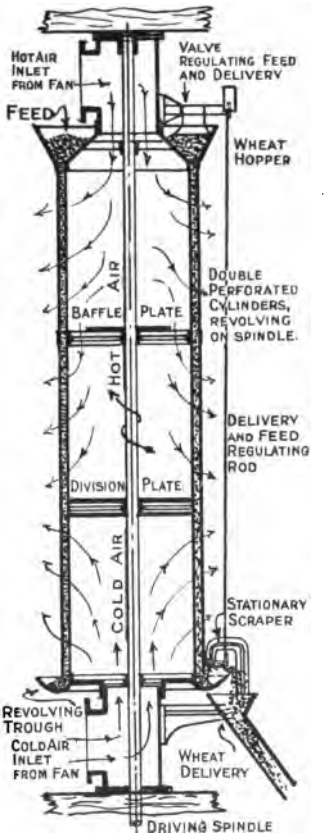

FIG. 58.—TURNER'S WHEAT CONDITIONER.

Turner Conditioner—Operation and Construction.—The machine consists of two vertical cylinders of perforated metal, one within the other, connected together and secured by carriers to a central spindle, which is rotated by means of a pulley and gearing fixed at top or bottom as required. Cylinders leave a grain space of 1¼ inch, which is divided by distance pieces running from top to bottom. This space is widened at the top into a hopper, while at the bottom it delivers the grain into a shallow circular trough. The hopper, double cylinder, and channel all revolve together slowly. The grain is fed into the hopper at top, fills each section as the machine revolves,

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and finally, by a succession of sharp drops, 15 to 18 per minute, reaches the shallow channel at bottom and is diverted into delivery spout by a stationary scraper. This scraper is connected by rods to a pivoted flap valve riding on the wheat in the feed hopper. The increase or decrease of feed automatically regulates the delivery by lifting or lowering the scraper. For the first two-thirds of its depth the conditioner dries, and for the last, the bottom third, the cooling process takes place. The division is effected by a cast-iron plate within the cylinders. The hot-air blast is supplied by a large fan, drawing air through a nest of steam pipes, and discharging it into interior of cylinders, and the cold-air blast by a fan taking from the atmosphere direct, see Fig. 58.

Messrs. Robinson's "Mallinson's" Conditioner—Description.—The machine on one side consists of two vertical steel casings down which the wheat flows, being checked in its fall and turned over at intervals by inclined slats. Inside the casing are vertical rows of steam pipes. On the other side, the casings contain no steam pipes. For the first half of this section, hot air is drawn through the wheat. For the second, bottom half, no heat is allowed, the air being drawn from the open. Beneath each inclined slat is a slot through the casing, and this at intervals admits the air suction, see Fig. 59.

The wheat feeding into hopper in section A falls on to a hinged valve board, or gate, which is connected by rods with the bottom outlet gate and opens or shuts down this gate as the feed increases or decreases at top. After passing down section A, and being subjected to hot air and heat by contact through and with rows of steam pipes, the wheat is elevated to other side B, and is treated to hot and cold air currents in turn, before finally discharging at bottom gate. A steam chest, placed beneath the conditioner, supplies the heat, and one large fan supplies the suction for all air currents, whether hot or cold, by a skilful arrangement of trunks and "cut-offs."

In the "Simon" patent drying, cooling, and conditioning machine, the air currents pass through the descending stream of wheat from left to right and from right to left, as the series of ducts are arranged on opposite sides of the wheat columns. It is contended that this alternating is more efficient than the "one side suction," as it attacks the wheat on both faces of the stream and leaves no wheat berries untreated. In summing up, the methods in brief are: (1) A circular, divided, double screen, rotating—the drying and conditioning medium being

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a hot or cold air blast from within—as in Turner's machine; (2) a flat, continuous, vertical double screen, with hot and cold air blast, from within and without alternately, as in the "Simon"

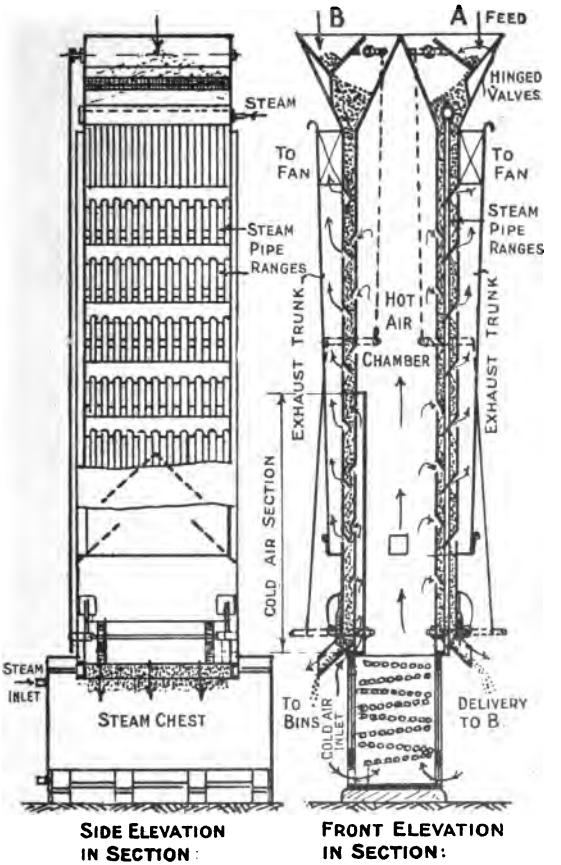

FIG. 59.—ROBINSON'S WHEAT CONDITIONER.

type; (3) flat, broken, double screens arranged in zigzag order, the hot and cold air blasts being passed through the screens and wheat turnover, as in the "Reform" type; (4) double vertical screens in pairs. The first section containing

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drying steam-pipes ranges, over which wheat passes, walls of screens, being louvred at back and at front for turnover of grain and for inlet and egress of air currents, supplied, whether hot or cold, by one fan suction—as in the Mallison type; (5) vertical, flat, continuous double screens, hot and cold air blasts applied from within and exhausting through grids at front, as Britannia type; (6) four-sided wheat columns, operating separately. Separate hot and cold air blasts, guided through the wheat by louvres, in an inpinging downward direction, and exhausting through perforated cover into the open, as in the Higginbottom type.

Moisture tests, and for the operative, chewing, feel and sight of wheats, are the usual tests as to condition. Weight is also to a certain extent a criterion. A simple mechanism, made by Messrs. Robinson, is now in use, which registers the fluctuations in weight and quantity of wheat passing from the conditioner, and therefore to that extent, heat, feed, and air currents remaining the same, is a condition test. Grain is remarkable for its habit of changing ahead of the weather, due probably to the sensitive skins which alter with the slightest hint of changes in the moisture percentage of the atmosphere. An experienced operative can tell fairly accurately, by feeling and by chewing grain, any big variations in the weather twenty-four hours ahead. The operative must constantly handle and test the finished grain, especially in steamy weather. The general effect, upon the main types of wheat, is as follows: *Hard and harsh wheats*, decided gain in tone and general milling condition, no strength lost. *Clean, hard and mild reds*, retain milling qualities if treated expeditiously. *Mild and soft sorts* general hardening and improved milling temper, slight loss of strength. *Natural bad condition, soft types*, lose moisture percentage, are hardened and toned. The loss of strength is not seriously important because one does not look to these to supply any strength element. The harder and harsher the wheat, the more latitude can there be exercised in the conditioning treatment. It is only when we come to soft, weak sorts that the greatest care should be taken to avoid over-treatment. Such wheats as Goose, Durum, Taganrog Cones, and the worst Indians will stand a good deal of conditioning. The most valuable strong wheats, such as Americans and Canadians, will require more careful exposure; and native wheats from a damp harvest season will be the most troublesome to deal with, but will respond well and profitably to close attention.

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It is generally found that the conditioning is more apt to soften and weaken the grain than to improve in any way the strength quality, and these points must be watched. The wheat has now been thoroughly prepared for grinding, and after standing for 12 to 24 hours in the grinding, or blending bins, will be passed through the final polish brush, and on to the I break-rolls, where we shall follow carefully its treatment in the gradual reduction system of roller milling for its conversion into flour and offals.

Weather Effects upon the Cleaning and Conditioning Plants.—Treating this broadly under the heading of dry and wet cleaning and conditioning plants, changes in the dryness or humidity of the atmosphere are felt most immediately here. Grain often becomes clammy in damp weather, and doubtful parcels will then develop their evil tendencies, hence constant treatment and turning-over is necessary. In the dry-cleaning plant, humidity somewhat decreases the capacity of the machines, especially the cockle cylinders, but suits the scourer, there being less danger of attrition. Very hot, dry weather has the reverse effect. Sudden changes, from hot to very cold weather, causes clamminess and the same troubles as humidity. In the washing and conditioning plant, the greatest inconvenience from the changes in the atmosphere will be experienced. A damp or humid day will appreciably lessen the capacity of all the machines, and the tendency to clog will make itself felt in the conditioner most severely. A constant watch must be kept upon this machine, or chokes and overflowings will give trouble. To successfully fight a humid atmosphere, all driving belts and pulleys must be in thorough repair. The washing must be moderate, with a final sharp rinsing just before whizzing. The whizzer must be kept free to fling off extraneous moisture, and the air currents and pressure of steam in the conditioner and dryer must be increased, to more thoroughly free the wheat of *incorporated* water. Fans must be kept at their maximum speeds. Give the dryer delivery gates a slightly increased opening and watch all flat or double-angled spouts, where the feed is most likely to slow down and cause stoppages. Very dry weather, either hot or cold, does not often happen in most English counties. It has the reverse effect, of course, to humidity. No difficulty is experienced with the feeds, but more steaming of brittle, dry wheats—less heat on the dryers, and more water on the washers—will be found necessary.

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Blending or Clean Wheat Bins.—When used in conjunction with dry-cleaning plants these bins are really the only means for the conditioning of the wheat, and take the place of the artificial conditioning plant almost invariably used with the washing process (or wet-cleaning plant).

The wheat mixture feeding in from the dry-cleaning plant will be composed of a wide range of wheats (say, for instance, Indians, Russian, English and Australian). They will be together in the bins for at least twenty-four hours, and will, to a limited degree, assimilate certain properties. The natural dampness of the English berries will be taken up slightly by the Indian and Russian. This will tend to make the Indian wheat skins less brittle and Russians softer. It is highly important that these bins, above all others, should be kept clean and well ventilated, and there should be no tendency, on the part of the wheat, to clog or cake together. If it could be "turned over" once, so much the better for the wheat. It is best to feed these bins through a movable wire-mesh basket or grid, to catch odd strings, etc.

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CHAPTER XV

HANDLING OF SCREENINGS

Screenings—Their Handling and Disposal.—Whilst in the smallest and even medium sized mills the impurities and foreign seeds other than wheat, extracted during the treatment upon the dry-cleaning plant mainly, can be disposed of with comparative ease and only moderate risk of loss, yet in the large mills, dealing with all classes and grades of wheat, containing great varieties of these screenings, the question of the best treatment is one of importance. Hence we find machines, appliances and elaborations of flow in the latter mills which have no place in the former. Many mills use the high-speed metal grinders now on the market, reducing to a meal the majority of the seeds and sending them on to mix in with the offals. This is quite legitimate, as the seeds mostly make good feeding stuff, many indeed being composed partly of broken wheat, with the exception of a few of the worst types of cockle seeds which are of a poisonous nature.

Good barley and oats are often well washed and sold whole, barley especially responding remarkably well to such treatment. It usually finds a ready sale amongst the maltsters. As a rule, however, all other seeds, screenings, chaff, and light beeswing from conditioners are ground up as already described The following list includes the majority of the screenings separated from the wheat parcels in their long passage through the cleaning departments :—

Type of screenings.	Machine from which obtained.	Description of screenings.	Disposal.
Coarsest tailings.	Rubble reels, sifters and warehouse-separators, and all machines with large hole screens in preliminary cleaning.	Sacking, sticks, strings, maize, cobs, stones, coal, wood, earth-balls, papers, and general large refuse.	Burn or tip to waste.

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Type of screenings	Machine from which obtained.	Description of screenings.	Disposal.
Heavy secondary tailings.	Warehouse separators, zigzags, and other separators.	Maize, stones, clay, peas, dirt, convolvulus seeds, beans, short sticks.	Dangerous to grind unless stones removed, chicken food.
Light tailings.	Lower sieves of zigzags and other separators.	Wheat ears, short straws, chaff, large seeds, oats and barley, and large wheat.	Further separate for good seeds, throw residue to fowls.
Screenings.	Screenings tips of wheat separators, zigzags, aspirated rotary sieves and reels, scourers and brushes.	Light weevilled and broken wheat, chaff, straw particles, oats, bunt, dust, seeds.	Grind for meals or offal mixture.
Heavy sandy dust.	Reels in preliminary cleaning, last sieves, w'hse and zigzag separators.	Sandy, silt and dried mud, with no nature.	Tip to waste, a nuisance.
Exhaust dust.	Dust extract plant, textile and other collectors from fan-exhaust of most machines.	Light fine particles with chaff and stive.	Tip to waste, a nuisance.
Mud dust.	Dust hopper scourers.	Light friable dried mud.	Tip to waste, a nuisance.
Mud.	Washers.	Heavy sludge, seeds.	Thrown on light land.
Stones.	Washers, stoners, and screens	Heavy pitted stone fragments, with some large wheat grains.	Thrown on land to fowls.
Chaff and beeswing.	Effluent recovery plant, brush, and conditioner fans and aspirators.	Light filmy skins from dried grain, and mash recovered from whizzers.	Use as litter, or send to offals.
Small round seeds.	Cockle cylinders, and cockle extract machines.	Cockle and other small seeds, broken wheat.	Grind for meal, or to mix with offals.

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Type of screenings.	Machine from which obtained.	Description of screenings.	Disposal.
Rye.	Rye separators.	Rye, thin wheat.	Grind for offals.
Barley and white oats.	Cylinders and separator sieves.	Barley, oats, and large wheat grains.	Further separate, sell barley for malting.
Blackoats.	Separators and cylinders.	Oats, barley, large wheat grains.	Grind for mixing in offals or sell whole.
Hollow, smutted, or weevilled grain.	Floated over from washer.	Hollow wheat, or filled with black powder, chaff.	Throw to fowls.
Garlic and aromatic seeds.	Seed sieves, aspiration, washer floatings.	Fine garlic bulbs and light seeds.	Burn or otherwise destroy.
Peas.	Large screen separators.	Beans and Indian peas usually.	Grind for pig meal.

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CHAPTER XVI

WHEAT BLENDS AND MIXTURES

THE miller has a constant battle to wage in selecting wheats for his blends on the mill. The most reliable wheats will vary from season to season. Keenly alive to changes and poor grading, to condition or the want of it, the miller must so blend his wheats that the best qualities of each have the greatest chance of being effective in the resulting flour and loaf. At present the miller is guided mainly by the qualities of flour and the qualities of the bread, from any particular mixture. The main lines upon which flour is judged are: (1) Colour; (2) quality of gluten (strength); (3) weight and percentage (the latter should, for a "straight run," be approximately 70 per cent.). The loaf is judged upon: (1) The texture of the crumb; (2) the colour of both crumb and crust; (3) the strength, shown in shape and bulking of loaf and crispness of crumb; (4) the flavour; (5) the number of 4-lb. loaves obtainable from a sack of flour, in which is included the water-absorbing powers of the flour. The price which the flour and offals will fetch on its merits in the open market, in competition with other makes, must be very fully considered in relation to the cost of the wheats collectively, and the cost of the preparation and manufacture. From the list of wheats already dealt with, under the headings of "weak," "medium," and "strong," lists under the headings of "coloury," "white," "bloom" and "sweetness," "flour yield," "strength" and "bulk-producing" can be compiled. The term "coloury" implies a flour with a fine creamy bloom in the shadow, the best qualities of Australian lead the world in this respect, and are used with special regard to this property. The finest whites are obtained from White English, Indian (White Bombay or Delhi), Oregon, Chilian, Red Plate (in best seasons). For flour yield the best whites and reds of a medium to large grain are most to be depended upon. These are mainly Dry White

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and Red English, Best Indian, Best Duluth, Northern Spring, Hard Manitoba, Best Russian and Danubian and Australian. Some of the dry White Americans, such as Oregon and Californian, yield well also. The worst qualities of all these wheats are the lowest in the scale for yield, due to the ravages of frost and blight usually. Frosted, shrivelled, and immature grains are robbed of a good deal of their flour bag. Included in this list will also be poor grades of Plate. The sweetest loaves are obtained from flour made from best dry English (Lincolnshire is good), Red Winter, Soft Canadian, Michigan and sometimes Australian. The best bulk-producing wheats are those whose flour gives the largest high-piled loaves, giving a porous, well-expanded elastic crumb. Such flour must contain the highest qualities of gluten, and these naturally come from only the strongest wheats. All the strongest types are red, therefore our choice is narrowed down to a few. In the main, these will be *Hungarian, Spring American, Manitoban,* and *Russian,* the best grades only of course. Hungarian is only occasionally available, so that we have only three countries on which to rely for these desirable strong-quality wheats—America (U.S.A.), Canada, and Russia. The two Americans give the better colour flour and crumb, the Russians being somewhat darker. The majority of wheats, especially the reds, are usually improved in the flour yielding and baking qualities by the effect of a few months' storage. Some wheats produce a yellow-tinged flour and loaf crumb. These include Indians (Kurrachee especially), Persians, Walla, Turkish, Hard Taganrog, Kubanka, and low grade Russians, low grade American, Canadian, Plate and English (Cones). Some produce a *dark loaf, close and unpleasant.* These include any smutted, frosted, or badly cleaned low grades of wheat. A *small, dense loaf* is produced from the flour of such wheats as Californian, Walla, Oregon, Persian, Egyptian, Hard Chilian, and second grade Indians. *Unpleasant-smelling bread* emanates from flour of tainted wheats. The presence of foreign scents usually conveyed by aromatic seeds, rotting or heated packets of wheat, or garlic and the like, all tend to taint the mass of grain, susceptible as it is to any odour. The principal offenders in this respect are Indians and Californians, containing spicey seeds; and English containing garlic. These odours spring to life in the baking, and such grain should be either avoided or treated with great care. It may be taken as broadly correct that

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English mills produce flour of fair strength, of good colour to mild and white.

In large mills it is usually continually necessary to grind small parcels of fresh arrivals and make a baking test to avoid any risks when dealing with huge quantities in the mill. In small mills, say eight to ten sacks, the miller depends upon his knowledge of the particular wheats purchased and the results he has obtained from previous similar mixture, bringing into play, of course, his judgment of the current season's wheat under consideration. He decides whether or not a certain " earthy " brittle wheat such as Kurrachee shall be steamed before mixing in with others for cleaning and conditioning purposes, and whether a wheat in almost perfect condition shall be left out of the washing and drying process, and after dry-cleaning sent direct to the blending bins to meet other wheats.

It is a well-known fact that in a washed and conditioned wheat mixture feeding to I break, it is decidedly difficult to pick out the various wheats present. This is a good proof of the efficiency of the tempering process, because the thin hard wheats have filled out, the brittle and harsh-skinned wheats softened, and the big damp samples have contracted somewhat, each diverse sort going halfway towards its neighbour in appearance, and thereby meeting on common ground. Forty to fifty per cent. of flour made is the maximum possible to grade as best or patents.

We have in the foregoing lists, the wheats giving the strongest, whitest, and largest percentage of flour respectively. With these ideals before us, we must decide what the mixture must be to suit our particular trade, and then proceed to adjust and substitute wheats obtainable from existing supplies consistent with prices, at which a reasonable profit on the resulting flour and offals can be obtained. A miller must be particularly long-headed in this respect, as it is now necessary to ascertain what wheats are approximately the equivalents of the ideals. To further guide him in his decision the miller has the forward shippers' samples of the overseas consignments, which, if honest specimens, tell him whether or not the particular wheat is up to standard.

Wheat Substitutes.—The five strongest wheats cannot be exactly replaced. A larger percentage of the nearest substitute must be used, thus—

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2 Red Winter = 1 Duluth. 1 Canadian White.

3 Danubian Red = 1 Spring American. 2 Kansas Winter.

1 Red Plate, 2 Spring American, 1 Duluth, 1 Red Winter = 2 Saxonska. 1 Red Winter. = 2 Chicago Spring.

The whitest wheats can be replaced thus—

1 Californian, 1 White English = 2 Australian, Oregon or finest Chilian.

1 Soft White Bombay, 1 White English = 2 Californian, Oregon or Australian.

1 No. 1 Blue Stem = 1 Choice Californian, Oregon or Australian.

The best yields can be replaced thus—

1 Red English, 1 Red Plate = 2 Canadian Red Winter.

1 Danubian Red, 1 Finest Azima = 2 Kansas or Colorado Winter.

To attempt to lay down rules and regulations or to give tables of the best standard mixtures of wheat for English milling, is of no practical use, because of the constantly changing conditions; all one can do is to lay down the broad lines upon which such percentages can be planned. In this country flour comes either under the heading of Baker's or Consumer's flour. It is usual, in mixing for a strong Baker's or household flour, to choose two or more strong varieties of wheat as a "backbone," and then fill in for bulk and whiteness with cheaper, weaker sorts. The percentage of strong wheats ranges from 30 to 60 per cent. according to the district and the demand. In the London and Midland districts, a flour of strength, soundness, and whiteness is in demand; whilst in the North a strong to average flour is made, coloury to white. Yorkshire especially, up till quite recently (and in this might be included North Ireland), were content with a coloury flour of a somewhat weak soft nature. As far as the author can gather, there appears to be a "levelling-up" tendency throughout the country, the districts being apt to overlap, and the removal of prejudice resulting. From wheat mixtures seen from different parts of the country the verdict of a

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" fair strength, good colour " seems just. To obtain a strong flour of fine colour is a difficult task, when one considers that competition and a profit debar many millers from using the high-priced, high quality wheats in any quantity. A straight-run London Baker's flour can be made from the following mixture :—

4 No. 1, Manitoba 8 North Russian	Strong
4 Red Kurrachee 2 Calcutta 4 Plate	Medium
4 English	Weak

A Liverpool Baker's flour mixture is the following :—

6 North Manitoba, No. 2 8 South Russian	Strong
4 Plate 3 C. W. Kurrachee 3 Red Kurrachee 10 Australian	Medium

The following are samples of mixtures giving fair strength and whiteness :—

10 Red Winter.
6 Plate.
4 Australian.
8 English.
4 C. W. Kurrachee.
2 No. 2 Hard Manitoba.

6 Northern Spring.
4 No. 1 North Manitoba
8 Delhi.
6 Kurrachee.
4 English.

5 No. 1 North Manitoba.
3 Ghirka.
4 Plate.
3 Calcutta.
2 C. W. Kurrachee.
2 Red Kurrachee.
3 Australian.
2 English.

3 No. 2 Manitoba.
4 Azima.
2 Ghirka.
6 Ros Fe Plate.
6 C. W. Kurrachee.
4 English.

Strong mixtures are the following :—

8 Ghirka.
2 No. 1 Manitoba.
4 Danubian.
6 Red Plate.
4 Chilian.
3 Australian.
2 English.

4 Danubian.
9 South Russian.
12 C. W. Kurrachee.
2 Walla.
3 English.
6 Australian.

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SHORT WHEAT MIXTURE SUITABLE FOR "STRAIGHT-RUNS"—MILD FLOUR.

All lower grades of wheat 50 per cent. strength.	40 per cent. strength.
2 Red Winter.	4 Russian.
3 Russian.	1 Walla.
3 Indian.	3 English (red).
2 English.	2 Indian.

Average quality flour in both strength and whiteness (few patents).

BEST AVERAGE MIXTURES FOR GOOD STRENGTH AND BAKING QUALITIES.

49 per cent. strength.	50 per cent. strength.
8 Spring American.	4 Ghirka.
40 Ghirka or Azima.	2 English.
30 Plate.	2 Red Winter.
20 English.	2 Californian.

To look into theory somewhat may be useful, always bearing in mind that circumstances invariably force one to choose a substitute or substitutes for any particular high-standard wheat in respect to either strength, bloom, or whiteness. Blend of good Baker's flour should have approximately 35–40 per cent. of strong red wheat, and should produce from ninety to hundred 4-lb. full-weight loaves per sack of 280 lbs.

To sum up this section on wheat mixtures, the main point to be watched by a miller is that he allows no big variation to occur throughout the season in the strength percentage. He must also be on the guard against so-called strong wheats, which, by reason of some occasional fairly strong samples, have got a reputation for strength which they fail lamentably to fulfil when put to the test. This type of wheat often contains a large percentage of crude gluten which fails to stand the test of baking, and results in a weak and disappointing flour and loaf. Some grades of Indian have this peculiarity and should be used as a medium and bulking wheat only. He should avoid excessive use of wheats tending to give a coarse and quickly drying loaf, even if such practice brings, for the time being, an extra profit.

In connection with this mixing and blending problem it is useful to bear in mind the numbers of 1 to 1½ sack self-contained plants now on the market. Those, consisting usually of cleaner, rolls, plansifter grader and dresser, and necessary conveying, elevating and driving tackle, offer the large miller a good chance of making fairly exhaustive tests of various wheat parts before final milling on large plant.

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CHAPTER XVII

THE GRADUAL REDUCTION SYSTEM

A COMPARISON with the old system of reduction by stones in one operation.

It is now widely recognized that wheat cannot profitably be reduced upon stones. The method is too crude and haphazard for a scientific age. The material, even in such excellent stone as French Burr, is too friable, uneven and coarse in texture to obtain the requisite fine groovings for a gradual reduction of the wheat berry. On stones, the wheat was reduced in one operation, and the resulting pulverized mass was then dispatched for grading and dressing. Fig. 60 illustrates the method of dressing or furrowing the faces of the stones. The grooving did not radiate from the centre of the stone, but was set out at a tangent, from the " drift " circle. The main grooves, or " master furrows," varied in number with the number of " quarters " into which the stone surface was divided. The smaller furrows intersecting the remainder of the quarters were termed " secondary furrows." The top surface of the stone left between the furrows was termed the " land," and was usually " snecked " or " cracked," to give the maximum grinding power. The grinding action was obtained by fixing one stone and revolving the other against it. The general practice favoured fixing the bottom stone, termed the " bed-stone," and rotating the top stone, termed the " top-stone runner." The feed of wheat was shovelled into the " eye " of the stone by a shaker or joggle feed, and, getting into the furrows, was dragged over between the surfaces of the land, in widening circles, until it finally fell out round the circumference of stones in the form of meal. The centrifugal action of the revolving stones helped this to travel outwards. The duties of the furrows were threefold: (1) To distribute the wheat and meal over the grinding surface; (2) to partly reduce it; (3) to supply air for ventilation (or to act as ventilating " flyers ") tending to keep the

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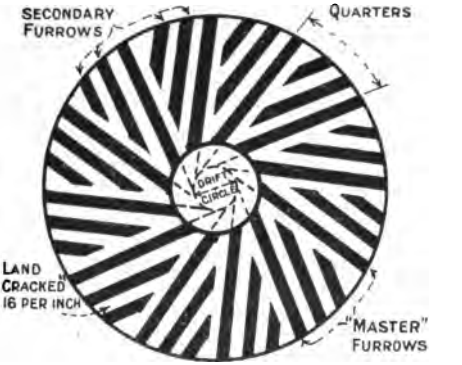
grinding surfaces cool. Two distances were recognized in millstones, to be maintained whilst in operation. *High grinding* (well apart for light treatment). *Low grinding* (set close for heavy searching grinding). A further reference to the diagram will enable the working of the stones to be more clearly followed. The scheme of "cracking" the land, or grinding surface, will be noticed, this being the first real grooving introduced in grinding wheat, and followed up in modern break rolls. The stones were supported either on a floor, or a special iron or timber hursting.

When the stone milling began to be seriously threatened, many exhaustive experiments were carried out to determine what the millstone was really capable of. Stones with ten, twelve, and sixteen quarters were tested, with one, two, and three furrows each respectively, but while a marked improvement was effected over the older style of stone dressing, the best work was far behind the roller system.



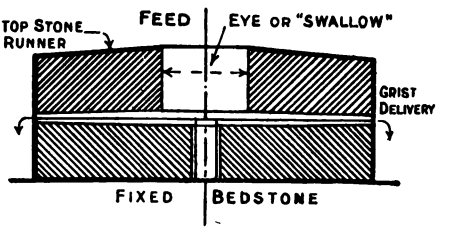


FIG. 60.—MILLSTONE DRESS.

It was found, in most cases, that the greater the number of furrows, the more severe the treatment of the wheat became. Stones 4 feet diameter, and at a speed of 120 revolutions gave most satisfactory results. Stones were usually run with the sun (clockwise). One of the great disadvantages of stones, especially felt as the mills became of larger capacity, was the large fluctuation in power required. As may be understood, the increase of pressure over a 4-foot pair of stones soon

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doubled the friction, and power required to rotate them. Tests made upon a pair of 48-inch stones at 120 revolutions, and producing 300 lbs. of fine meal per hour, showed that they took nearly 10 H.P. Unless carefully dressed and run truly with a good even feed, the stock, or grist, from stones will be found heated as it discharges. This method of reducing the wheat berry favours the manufacture of a large percentage of fine pulverized bran, a most undesirable thing. All attempts to harness stone grinding to a gradual breaking-down and an efficient system of grading, purification, and dressing were found of but little real use, and the roller-mill of metal doomed the millstone to practical extinction. The modern idea of cracking or shearing open the wheat berry, in preference to crushing it, was faintly shadowed out, with the most efficient methods of stone-dressing. There the land and furrows of the bedstone were crossed scissors fashion by the land and furrows of the top stone runner, and the action was somewhat like that of the groovings on the latest break roll. In the early days of roller milling, several mediums were tried, porcelain amongst other substances being given quite a long trial as a smooth roll, reducing flour stock from the purifiers. But for general reliability and even wearing and freedom from cracking, under the heavy pressures used, cast-iron rolls deeply case-hardened by chilling in the mould, were found best, and have now become practically universal. Many strange ideas and theories were advanced, before the different phases and limitations of the new system were realized. What, then, does modern milling aim at, as differing materially from the old methods on stones? Instead of pulverizing the grains into one muddled mass of torn bran skins, burst flour bag, and vegetable tissue, it operates upon them by a series of steps, "breaking-down" the berry slowly, and at each operation, sifting away the freed particles of the endosperm, or flour-bag, before dispatching the opened grains to the next roll for further treatment. This goes on until nothing but the bran-skins remain, the whole of the interior having been removed. This section of roller milling, termed the break system, now consists of four distinct operations, or of breaking-down on four sets of rolls. At first, the highest possible grinding was performed on the I break roll, the remaining ones being called upon to do the real work. This led to the use of five and even six-break systems, in order to deliver nothing but perfectly

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cleaned wheat skins from the last break. These systems became rather unwieldy, and, as aspiration of all rolls came into practice, the trouble of "blue flour," which necessitated the gentle first break operation, was greatly diminished, and rather, more searching treatment made possible on this roll. A reaction took place, and three-break systems came into vogue Gradually the reasonable middle course has been found, and present-day systems of four-breaks are in the majority, and will probably be so, as long as milling by rollers obtains. The grooving of break-rolls is a matter of first importance. The shape, size, length, angle, and speed of grooves and cutting edges have a distinct bearing upon each other, and these must be maintained in the correct proportions. The standard "saw-tooth" or "German" type of grooving was evolved from many varieties of shapes, and standardized as in present-day use. Fig. 61 illustrates this shape, with the chisel

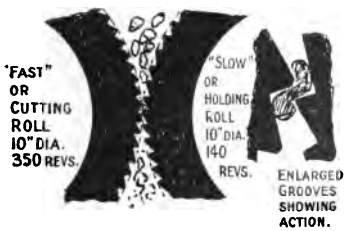

FIG. 61.—SECTION BREAK-ROLL GROOVING.

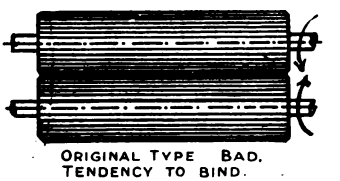

FIG. 62.—HORIZONTAL ROLL GROOVING.

formation of each cutting edge. It gives best results after a few weeks' work and wear, when the first keen edge has been smoothed away by the wheat.

Then comes the matter of angle at which these grooves are cut. At first a number of rolls had them cut parallel with the axis, see Fig. 62, and a distinct locking tendency was the result, besides failure to open out the wheat berry efficiently. Marks of the corrugations were left upon the bran coats. Grooves were then cut diagonally with the roll axis, and were also more or less a failure when run so as to interlock. The correct system was found when the spiral grooves were run across one another scissors fashion. A clipping action was obtained which opened the grains cleanly, with a minimum of friction and damage to stock. Special machines have been designed for cutting the spiral grooves on the rolls, and the

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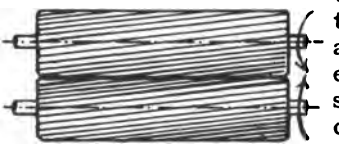
travel of the cutting tool can be so adjusted that the amount of spiral is increased or diminished at will. A good definition of spiral grooving is "The course a groove takes, which, while encircling a cylinder, advances along it at an angle with the axis." The angle has now been fixed at 12°, and can be considered the standard. Yet another matter had to receive careful attention before the roll became efficient and economical in breaking wheat. Whilst both rolls had, of course, to revolve toward each other, to carry stock through, one had to travel much faster than the other, no shearing being possible otherwise. The proportion is now fixed at $2\frac{1}{2}$ to 1. The slow roll grooves "hold" the grain whilst the fast roll grooves shear it across. Fig. 61 should be considered. It will be noticed that the fast roll has its corrugations with the short edges downwards, whilst the slow roll has its long sides downwards. This further assists the shearing action. The size of grooving for each roll in the break system is governed by the size of feed particles. In the case of the first break, the whole wheat to be treated, must be allowed sufficient space in the grooves, whilst passing through the "nip" of the rolls, to prevent any crushing action, and this must be followed on every other roll in the break system. Fig. 63 shows the correct position of the pair of grooved rolls. It may appear at first sight that these groovings will tend to cog in with each other and bind, as in the case of the horizontal grooves, but a consideration of the fact that the rolls rotate inwards at the point or edge of contact will prove the scissors action to be effected. The average diameter of rolls has been fixed at 10 inches. This gives the best period of contact when running; the angle at which the surfaces and grooves of a pair of rolls approach each other varies with the diameter. Thus an 8-inch or 9-inch roll gives a much sharper angle than the flat circumference of a 13-inch or 14-inch diameter, and the happy medium has been struck in the 10-inch.



GOOD.
CUTS AT AN ANGLE

FIG. 63.—DIAGONAL ROLL GROOVING.

Having now dealt with the main principles involved in the first section of the roller system, we will proceed to enumerate the complete list of operations, in order to point the way

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to the treatise to follow. They consist, in order of rotation, of: (1) ***Breaking down***, or opening the wheat berry, in a series of grindings, on grooved rolls (see Fig. 64 of break system); (2) ***Scalping***, or the gradual removal of the particles of interior flour-bag, in as large and uncontaminated a condition as possible, on sifting or pneumatic machines; (3) *Cleaning*, or scraping, the bran, on finely grooved rolls; (4) ***Bran-dusting*** and meal grading or dressing on sifting reels; (5) ***Chop system***, or preliminary grading and dusting of scalper stock on sieves or reels; (6) ***Purification***, or the final dusting, sizing, and grading of same stock, on a combined sifting and aspirating machine, which weighs the stock to a fine degree by upward currents of air, and dispatches

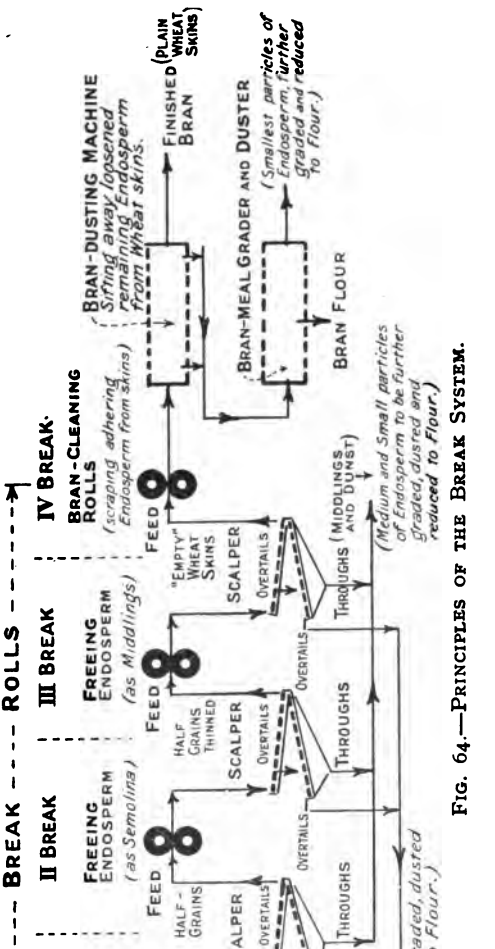
BREAK ROLLS
I BREAK
II BREAK
III BREAK
IV BREAK
OPENING GRAIN
FEED
WHOLE WHEAT GRAINS
SEMOLINA (Largest particles of Endosperm. To be further graded, dusted and reduced to Flour.)
OVERTAILS
SCALPER
HALF-GRAINS
FREEING ENDOSPERM (as Semolina)
HALF GRAINS THINNED
FREEING ENDOSPERM (as Middlings)
"EMPTY" WHEAT SKINS
BRAN-CLEANING ROLLS (scraping adhering Endosperm from skins)
BRAN-DUSTING MACHINE (Sifting away loosened remaining Endosperm from Wheat skins.)
FINISHED BRAN (PLAIN WHEAT SKINS)
THROUGHS
THROUGHS (MIDDLINGS AND DUST)
BRAN-MEAL GRADER AND DUSTER (Smallest particles of Endosperm, further graded and reduced to Flour.)
BRAN FLOUR
(Medium and Small particles of Endosperm to be further graded, dusted and reduced to Flour.)

FIG. 64.—PRINCIPLES OF THE BREAK SYSTEM.

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the groups to the different flour-making reduction rolls ; (7) *Reduction* of these particles, by heavy pressure between smooth rolls, to the fineness of flour ; (8) *Scratch* system, or the retreatment of semolina (the largest flour particles), to which bran-snips are still adhering, upon finely-grooved rolls, and special grading and dusting machines ; (9) *Dressing*, or the sifting out, on silk reels, or other machines, of the finest of the flour particles from the reduction rolls; (10) *Further grinding and dressing* of residue, until the safe working limit has been reached, when the hopeless muddles of flour and bran particles are tailed away and dispatched as offals ; (11) *Bran rolling*, or the flattening of bran particles into large flakes.

Fig. 64 will help to impress the method of linking up the separate processes upon the reader's mind. A list of the various machines used throughout the flouring section of the mill will now be useful (under the headings already referred to) : (1) Four-roller mills, with grooved rolls, either horizontal, vertical, or diagonal ; (2) reels, sifters (rotary or reciprocating) plansifters, and pneumatic scalpers—with covers of wire or grit-gauze ; (3) and (4) reels, centrifugals, or plansifters with wire or grit-gauze covers ; (5) reels, centrifugals, or plansifters with wire, grit-gauze and silk covers ; (6) purifiers, sieve or air-circuit types ; (7) four-roller mills with smooth or very finely grooved rolls, either horizontal, vertical, or diagonal ; (8) rolls as above, but finely grooved, and reels, centrifugals, or plansifters, with wire or grit-gauze covers ; (9) centrifugals, plansifters, rotary sieves, and sometimes reciprocating sieves for tailings, silk covers ; (10) more reduction rolls and dressing machines ; (11) large smooth rolls as for reduction. There are of course conveying tackle and spouts, but these do not really enter into the manufacture of the flour. In order to avoid confusion and to enable the student to understand the terms employed in following chapters, it will be well now to give a table, explaining each in turn.

Breaking down.—Shearing open the berry and extracting the contents.

Scalping.—Sifting away these loosened contents.

Dressing.—Sifting away flour particles.

Throughs.—Stock dressed through cover.

Overtails.—Stock passing over cover.

Tail sheets.—End section of dressing or grading cover clothed coarsely to dress through all but the largest particles, on centrifugals and reels.

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Cut-offs.—Similar end cover on purifiers.

Tins or trays.—Stock, lifted by air-currents from purifier sieve cover and deposited in trays of purifier.

Semolina.—The largest granular particles of endosperm released by the break rolls, dressing through from 18 to 40 mesh per inch.

Middlings or "Midds."—The medium granular particles of endosperm, released by the break rolls, dressing through 40 to 84 mesh per inch (includes two or three grades).

Dunst.—Finest granular particles of endosperm released by the break rolls and dressing through 84 to flour numbers (106) meshes per inch.

Flour.—Finely reduced semolina middlings and dunst dressing through from 94 to 156 meshes per inch.

Bran meal.—Soft branny stock, through 36 mesh.

Fine sharps.—A hopeless mixture of flour, soft fibrous stock, and bran shreds, through 50 mesh.

Coarse sharps.—A similar mixture through 30–40 mesh.

Fine bran.—Small particles of wheat skins passing through 14 mesh.

Broad bran.—Coarse or large particles of wheat skins passing *over* 12 mesh.

Greys.—Small particles of bran in flour or stock, which appear grey from beneath flour.

Blue flour.—Flour from breaks containing large percentage of cellulose matter (cell walls of endosperm) of a very light and filmy nature.

Beeswing.—Fine, filmy flakes of cellulose matter and single bran coats (badly adjusted scourer beaters often cause this).

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CHAPTER XVIII

THE BREAK SYSTEM

THREE types of four-roller mills are employed in breaking down the wheat berry. The horizontal, the vertical, and the diagonal. Each has special advantages, but modern practice favours the diagonal type as being most suitable for good all-round work. Roller-mills are made in which the rolls are placed two and three high in one frame. Whilst these certainly economize floor space, the distance of top rolls from the base renders the casing susceptible to vibration; the feeds and deliveries are somewhat complicated, some of the drives and gearings are out of reach, and pressures cannot be so finely adjusted as in the usual type of four-roller mill. All these points tend to keep the tall-framed mills out of the break and reduction systems. The three types of roller-mills are—

(1) The horizontal rolls, which can be easily adjusted as the weight of rolls does not come into play. Large floor space is taken up, vibration is liable to affect the pressures and render them uneven. They are now used mostly upon bran for bran cleaning, no heavy pressures are required in such work.

(2) The vertical roll, which has the advantage of more reliability on heavier classes of work, less floor space, and more uniform work. The delivery from the rolls can be easily inspected. It shows to least advantage upon light fine stock.

(3) The diagonal rolls combine the advantages of both the former types. The frame takes up an average floor space and height. The position of the rolls in relation one to the other, is so arranged that they approach each other at an angle when pressure is applied for grinding. This is a distinct advantage, obviating any tendency to injure roll surface or stock by sudden "gripping." The angle of roll axis, approximately 45°, is an ideal one at which to receive the feed into

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the "nip," an . facilitates the arrangement of feed rolls and shelves. Grist, issuing from the underside of rolls, can be readily examined, and the scrapers, in the case of the reduction rolls, set accurately. Reference to Fig. 65 of these three types illustrates the special features of each. Fig. 66, by Messrs. Robinson, and Fig. 67, by Messrs. Briddon and Fowler, illustrate the fine finish of these machines. The principles upon which these roller-mills are constructed and fixed, in order that they can perform the heavy work imposed upon them, while maintaining accuracy and easy running with the minimum of power per sack, is—

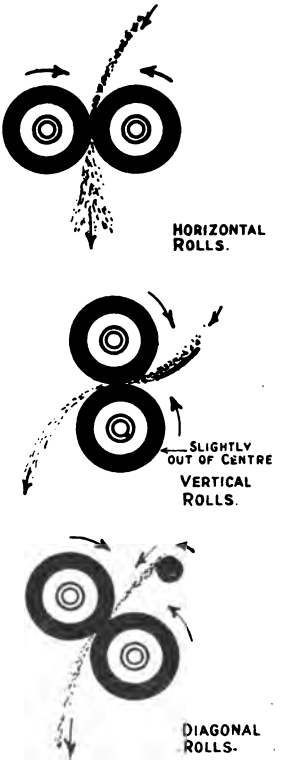

FIG. 65.

(1) *Rigidity*.—The frame and the mechanism contained in it must be perfectly rigid and solid, so that all stresses and pressures can be easily taken up. The roller-mill must be firmly fixed, avoiding all vibration.

(2) *Driving*.—Must be of ample strength, smooth-running, free from noise and jar, and reliable in uniform speed. Belts being apt to slip in this particularly severe form of driving, gear-wheels of the chevron type are in general use. Each pair of rolls being bound together, the exact differential speed is maintained, whatever the speed of the main spindle. The gears run in an oil-tight case, the oil rendering them almost noiseless. The main drive from the mill shaft is by belt.

(3) *Bearings*.—Taking the great pressures put upon the rolls and spindles during grinding, they must be of ample diameter and length. The minimum of friction and heating is obtained by maintaining an unbroken film of oil between the spindle and the bearing surface. All makers design each bearing with a self-contained oil well and an automatic circulation

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of oil to and from it. By renewing this oil when it becomes too dirty or too thick, almost perfect lubrication of the bearing is ensured—danger of heating and seizing is greatly reduced, and the power required is kept at the normal. The grit present in dirty oil causes friction and heat. The film of oil is almost useless in this case, and the only way to guard against this trouble is to periodically drain away or filter such oil. It is bad practice to merely keep the oil well full without regard to

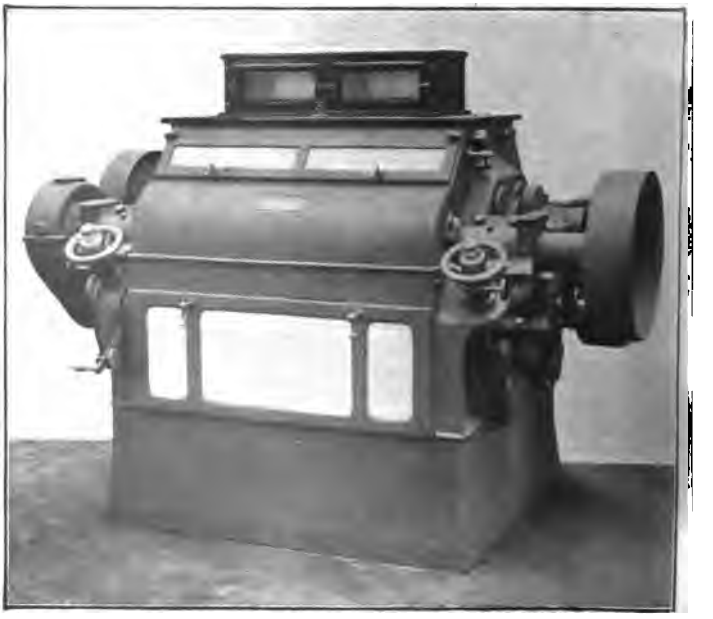

FIG. 66.—DIAGONAL FOUR-ROLLER MILL—ROBINSON.

the condition of the dregs. Special roller and ball bearings have been tried on rolls, but have not been adopted generally, as they are apt to wear unevenly.

(4) *Rolls* must have a very hard tough surface to resist the wearing action of the grains. The silica contained in the wheat causes this. It has been found that iron rolls cast in an iron

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mould, meet the case best, and for this reason. Immediately the metal is poured into the mould, the surfaces of molten metal coming in contact with it, are "chilled," that is, the metal suddenly cools and sets, thereby forming a crystalline structure of material, extremely hard. The interior of the hollow rolls, cooling at a normal rate, is not so hard, but remains tough and less liable to break or crack with a sudden shock or blow. An examination of the standard makes of rolls will reveal their wonderfully uniform texture and facing. When one considers the fine work exacted from the reductions, it will be seen how very necessary this is. The increasing use of very finely grooved

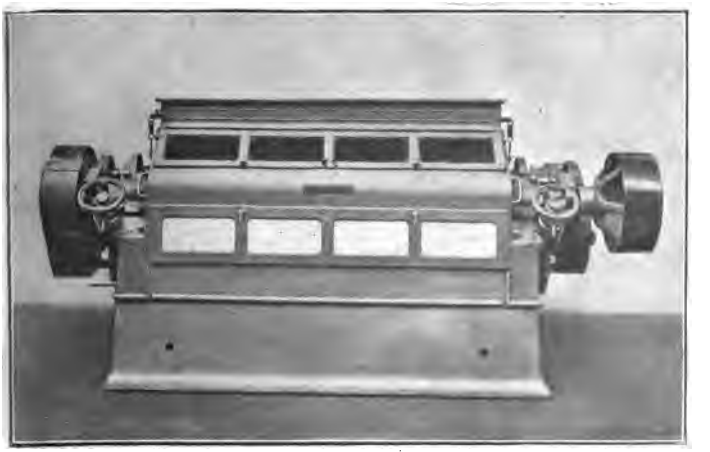

FIG. 66A.—DIAGONAL FOUR-ROLLER MILL—TURNER.

surfaces for these rolls, makes a further demand upon the absolute accuracy of the facing, in order that each groove may be uniform in depth and in truth. A sectional cut of the roll, examined microscopically, reveals the increased closeness and hardness of the texture at the guiding surface. Thus the body of the roll is strong to resist a bending or breaking action, and the surface to resist a frictional or wearing action. The roll spindles are of steel, and are driven into the hollow rolls by hydraulic pressure. The rolls must be absolutely true throughout, to the $\frac{1}{1000}$ part of an inch, and the depth of grooves (on breaks and scratch) not greater

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than half the diameter of particles ground, in order that they may not escape treatment.

(5) The adjustment of rolls should be under perfect control. It must be extremely sensitive and accurate, for upon this depends successful breaking and grinding. It must be quite evenly applied throughout the "inches of surface" or the length of rolls, otherwise the whole operation is inefficient. On the break rolls there is more danger of jarring, owing to the hard and large particles being treated. On the reductions the running is smoother, but a greater degree of accuracy is required. Both these features must be met by the mechanisms.

FIG. 66B.—DIAGONAL FOUR-ROLLER MILL—SIMON.

A slight change in the atmosphere or the condition of stock will often necessitate a correspondingly slight adjustment of the rolls—to either increase or decrease the pressure. The latest improvement in this section is the micrometer adjustment, a delicate and ingenious gear which will now be described. The micrometer adjustment has been designed in order to obtain the minute and extremely finely graduated setting of rolls, with a comparatively large movement of the handwheel. The gear is self-contained, and the different makes of rolls embody this idea, although they vary in detail. The usual method of

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application is that it operates the end of the movable-roll "lever" forming part of the roll journal. Its support is part of the solid c.i. roll frame. This is essential in order to ensure absolute rigidity of the gear when set. The mechanism operates thus, see Fig. 68. The tension rod, working pivoted lever carrying the roll, screws into the gun-metal nut, which is supported by a handwheel on a ball-seating and connected to it by a pin. The handwheel sleeve is threaded coarser than the tension rod, and a fine adjustment is obtained by the difference

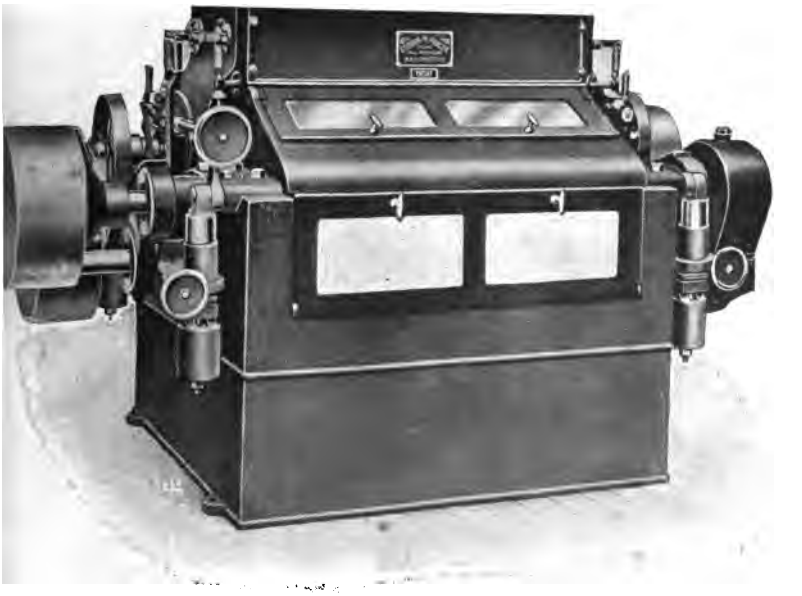

FIG. 67.—DIAGONAL FOUR-ROLLER MILL—BRIDDON AND FOWLER.

in pitches of threads on these two. The rolls can be brought together by moving the handwheel as the arrow, from left to right. One complete revolution will lift the handwheel $\frac{1}{8}$ inch up, but at the same time lower the tension rod $\frac{1}{11}$ inch. Thus the tension rod has actually moved up $\frac{1}{8}-\frac{1}{11}$ inch or $\frac{3}{88}$ inch.

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The leverage of roll-lever reduces this movement on the rolls to approximately $\frac{1}{100}$ inch.

(6) ***Throwing-out***, or moving the rolls apart when some obstruction requires removing, when the feed has stopped, or the mill is shut down for the week-end, must be easy and

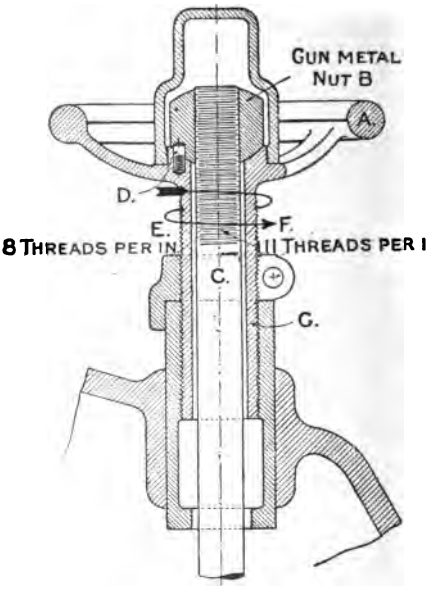

FIG. 68.—ROBINSON'S MICROMETER GEAR (FOR DIAGONAL FOUR-ROLLER MILLS).

rapid. In some roller-mills where the bottom roll is adjustable, this is accomplished by simply depressing a short lever, which operates an eccentric cam at each end of rolls by means of a rod running parallel to rolls. This lever engages, at its lower end, with an eccentric pin and boss, attached to the tension-rod carrying the pressure spring. This tension-rod is also lowered slightly, the pressure between the fixed and the adjustable rolls is removed, and a slight gap left between them. A clearance of $\frac{1}{8}-\frac{3}{16}$ inch being sufficient. The chevron gears must always be well in gear with each other. Throwing rolls wide apart would not admit of this, and would serve no useful

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purpose. The throw-out lever also operates the feed rolls, stopping them and thus preventing any feed passing unground. The compression-spring referred to, on which the adjustment lever and roll rest, is to allow the roll to "give" sufficiently to pass hard substances such as nails, which would otherwise damage the rolls, and to absorb vibration. The throw-out lever in some makes is *depressed* to open rolls, and *raised* for the same purpose in other makes. The handwheel sleeve, and with it the whole of the micrometer adjustment, is held firmly in place by the throw-out cam. By depressing the lever, the cam is lowered by the eccentric pin, and the whole adjustment gear follows down with it.

(7) *Stops.*—Rolls are provided with stop-pins, designed to prevent the rolls actually touching. For a fine finish, however, it is practically impossible to keep them apart, should the feed suddenly cease. The rolls are riding on the stream of material, and it thus serves to hold them apart. Stop the feed suddenly, and the great pressure behind the rolls will tend to bang them together.

(8) The *feed gear* usually consists of a feed hopper with hinged valve-gates and feed rolls. By means of adjustable pressure-spring gear the valve gates should be set to work automatically. The main duty of the feed gear is to widen the heap of stock in the hopper into a broad thin sheet of feed, which covers the whole length of rolls, in a consistently uniform spread of unvarying thickness. It is well to feed the rolls to the extreme ends to prevent the possibility of uneven wearing. Glass doors are provided for a good view of working and feed in hopper.

Roller feed-gears.—The most troublesome roll feed to deal with is that composed mainly of soft and branny stocks. If this type of feed can be efficiently regulated and spread it will be comparatively easy to manipulate other stocks. Messrs. Simon have devised a feed gear to overcome these difficulties, see Fig. 69. (A first essential is that the gears shall be readily adjustable, and that the gate shall be lifted clear in the event of binding feeds.) The regulating and adjusting lever A can be worked without opening the roller-mill door. It has three positions—of angular movement—rocking spindle B. In the first position it is thrust inwards sufficiently to "hold" the regulating link C, the bell-crank-lever D, and prevent the tension spring from coming into play against the feed plate. This is really the "locking" position. In the

second position the lever A is pulled forward to depress C sufficiently to free the bell-crank lever D and allow the spring S full play, thus putting into action the automatic feed. In the third position the lever A is pulled forward to its limit, and, lifting finger E up against stud extension F, raises the feed plate vertically. This latter operation can be done quickly, and allows any temporary clogging or obstruction of the feed to clear itself. The edge of feed plate and feed roll contact is exposed, and thus can be cleared by a spatula if desired. The makers claim this as an extremely sensitive gear.

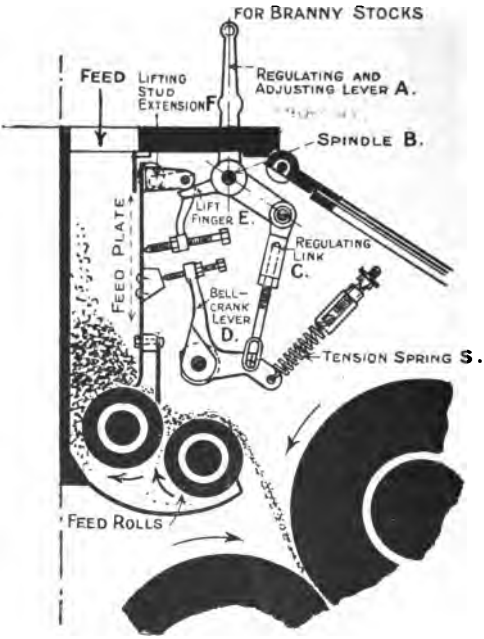

FIG. 69.—SIMON FEED GEAR—DIAGONAL F.R.M.

(9) *Exhaust.*—The main reasons for roll exhaust are the removal of humidity and heat and the lifting away of light soft flour dust and cellulose matter released at each operation. By means of the internal trunks, incorporated in the machines, the aspiration is applied to the grist as it leaves the rolls. Here it has the greatest effect. The heat generated by grinding, combined with a certain amount of humidity, is drawn away, thus keeping the rolls cool and free from the tendency to sweat. On the breaks a small percentage of light cellulose particles released from the berry, and termed "blue flour," is also removed, and contamination of the break flour avoided. Two trunks should be applied to each roller-mill, one at each end, and should be run into the side of the main exhaust trunks, as Fig. 88, to allow them to be periodically cleaned

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without driving the deposit back to the rolls. Automatic travelling scrapers or monkeys keep these clear. To be exactly effective the main exhaust trunks should be proportioned in sectional area to the number of rolls from which they are taking exhaust, at any given point *en route*. The average area of branch trunks is one square inch per 4 inches of roll surface, thus each pair of rolls on a 60 × 10 inch roller-mill will require $\frac{60}{4} = 15$ square inches inside area trunks = say $3\frac{1}{2} \times 4$ inches. A four-roller mill will thus require two such trunks, one operating each pair of rolls. Exhausting is especially necessary on last break rolls and on the "C" and "D" patents reduction rolls, where the heavy pressures necessary aggravate the tendency to sweat. The fans at work upon these rolls should be large and steady-running, and the tendency now is to exhaust from these into a tubular textile dust collector situated in the mill. All branches and connections should have slides for the regulation of the suction, and the economy of power.

(10) *Grooving*.—The standard German saw-tooth pattern of grooving is the best. For mixed wheats, with a four-break plant, a good working standard is I break, 8 to 10 per inch; II 16; III 20; and IV 26 per inch. When the mill is large enough to have two or more pairs of rolls to each break, it is often advisable, with a wide range of wheats, to size into two grades for I break, and use eight and ten grooves for the large and small grades of mixture respectively. Break rolls should not be run too long before regrooving. The amount of break flour will be increased, as extra pressure will be required to force the rolls to their full capacity. Extra power will be required. The percentage of pure semolina and middlings will be diminished, and, therefore, also, the patents flours. The bran will be deeply marked and crushed. The percentage of broad bran will be reduced. All the sharps will be too white and too plentiful at the expense of the flour output. Bran flour will be stained on damp days and mixtures. With groovings regular and fairly sharp to the touch, the percentage of semolina and middlings up to standard, the break flour small in quantity, the bran clean and "finished," and the work performed without undue pressures, the break rolls do not require regrooving. The average life of grooving on I and II break rolls is approximately eight to nine months. On III and IV breaks, where the stock has lost its first hardness, from twelve to sixteen months. It is advisable to regroove rolls alternately, so that only one pair of over-sharp rolls is at work at any time.

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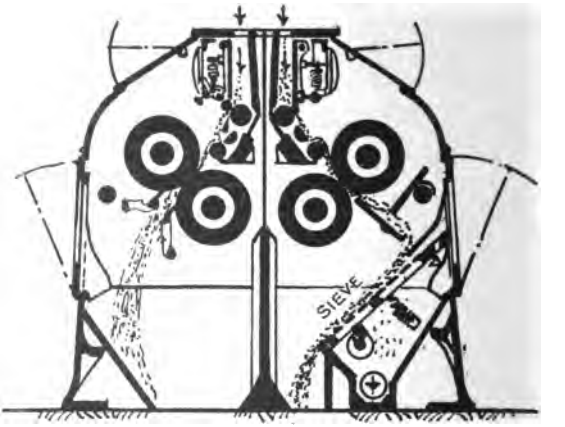
(11) *General construction* of roller-mills should be such that all parts are easily accessible. Feeds entering the "nip" of the rolls, or grist leaving the rolls, should be within easy sight and reach of operative for examination. Rolls as simply and strongly constructed as possible, self-contained and practically air-tight except at point of ingress of air supply to exhaust. Rolls must not work out of line after adjustment. They should be kept scrupulously clean and free from accumulation of moth or stock.

Some makers of rolls are adopting a roll-scalper system. That is, are embodying sieves or scalpers within the roll frames,



CROSS SECTION CROSS SECTION

FIG. 70.—SAMUELSON'S BREAK AND REDUCTION ROLL SECTIONS.

so that the grist falls directly on to these as it leaves the rolls. The released stock is removed, and the remainder of the berry passes on to the following break direct, see Figs. 70, 71.

Break roll sizes and surfaces.—The 9-inch diameter rolls are usually made from 20 to 32 inches long, fast roll, 375 revolutions, gears $2\frac{1}{2}$ to 1.

The 10-inch diameter rolls, the standard size, are made 24, 32, 40, 50, and 60 inches long respectively, fast roll 350 revolutions, gears $2\frac{1}{2}$ to 1. Although most makes of roller-mills have equal-sized pairs of rolls, one well-known firm of milling engineers advocate the use of differential sizes, 10-inch and 13-inch diameter rolls pairing.

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The actual standard travel of roll peripheries is approximately 900 feet per minute for fast or "cutting" roll, and 360 feet per minute for slow, or "holding" roll. The stock travels through the rolls at approximately 450 feet per minute. The size and number of rolls in a break plant is determined by the standard set, in "inches per sack." This term meaning the number of inches of roll length, or contact, employed for every sack of the mill's capacity per hour. From 30 to 40 inches per sack is the range of practice, spread over a four-break system in certain proportions.

A 30-inch break surface would be divided up thus . . .	I 7 in.	II 8 in.	III 8 in.	IV 7 in.
35-inch (average practice) .	I 7 „	II 10 „	III 10 „	IV 8 „
40-inch maximum . . .	I 9 „	II 11 „	III 11 „	IV 9 „

It will be noticed that there is a method in this uneven division of surfaces, and that the II and III breaks always receive the most. The reason for this lies in the fact that the heaviest work, the releasing of the greater part of the semolina, middlings, and dunst, must be done on these two rolls, and that therefore extra surface must be granted, to keep the feeds as thin as consistent with good work. The I break has only to crack open the berries, and on the last, the IV break, the bulk of the stock has been removed, so that, although the inches of grinding surface are less than on the previous rolls, the proportion of surface to actual feed is really greater. This should be so, because the bran coats must be finally and completely "finished" and "cleaned" without further abrasion and powdering. Break systems have ranged from three to six separate operations. For some time the three break was in favour, but experience condemned it finally upon the following counts: (1) The sudden change in size of grooves from coarse to fine destroys the larger flakes of bran and makes too much fine midds and dunst in place of semolina; (2) the greater pressure being required, there is the tendency to crush the grain and make too much break flour; (3) the increased pressure develops heat, and rolls will require more attention in working, lubrication, and aspiration; (4) to thoroughly clean bran in three breaks, the sudden breaking down will mean bran fibre shredded on the I and II breaks, to the detriment of all break and purifier stock. The five and six breaks systems, although still practised in some mills, have not much to recommend them. It must be clearly borne in

mind that the four-break system does not employ less actual roll surface per sack, than in the five or six-break systems. The balance is kept by giving each break more surface. The net gain is, that the stock gets the minimum of friction and handling, consistent with proper breaking-down, and that each break-feed has ample surface on which to pass the maximum stream without over-crowding.

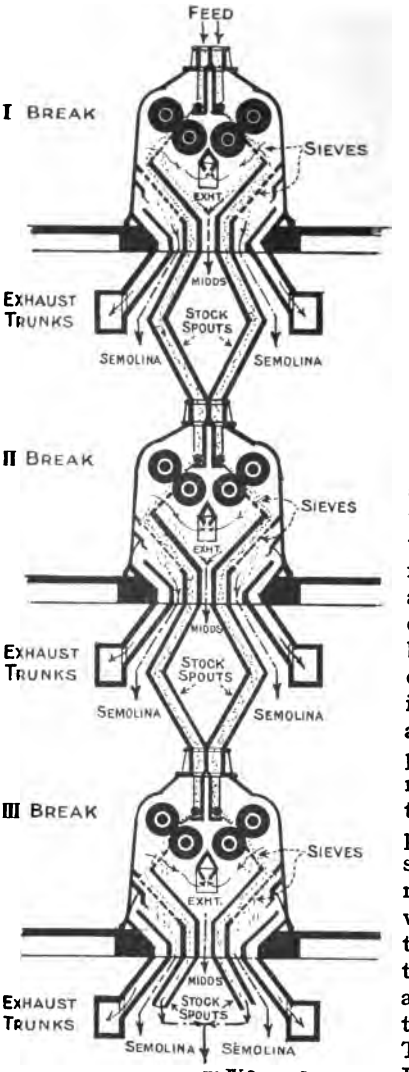

FIG. 71.—REFORM ROLL SCALPER.

Rules for rollermen — Break system. — In starting up the rolls, they must be carefully timed and in easy running, ready for final adjustment as the feed enters. The feed to I break must be examined closely to determine that it is even in quantity and condition. The pressure upon this roll must be adjusted until the maximum feed is passing in a broad even stream right across the rolls and into the "nip" with precision. Constant touch must be kept with the screenman to guard against any likely variation in state of mixture. The work of succeeding II, III, and IV breaks must be quickly followed

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up in succession and the pressures set for each quality of feed. The bran skins should leave the last break in well-opened and well-cleaned flakes, free from grooving impress. A final adjustment will probably be found necessary, to either ease off or put on pressure, to meet the slight variation caused by the rolls warming to their work. Periodic handling of all break stocks, to and from rolls, is very essential in order to check the work of the rolls. Care should be taken that the work of the scalpers ensures finished stock grading away and not feeding to following roll. Large percentages of break flour must be avoided. The reduction rolls will next require attention, one after another being carefully adjusted and set to a nicety until the whole range is fully employed. A special set of notes will be given in the reduction section.

To deal with matters applicable to either break or reduction rolls. Throughs of scalpers and dressers should be obtained so that it can be ascertained that the rolls are providing the correct feeds. A closely-worked report of the first hour's run must be taken by the packers. This will enable the roller-man and foreman to check the flour percentage in the aggregate and in the various grades, enabling them to gauge the work of the rolls. When all is in good running order, a constant watch must be kept upon the various drives, bearings, and mechanisms of the rolls. The sound of the running is a criterion of any defect or otherwise. Slipping belts, heated bearings, uneven feeds, or rolls out of truth, are the greatest troubles. Heated bearings often cause the "out of line" rolls, the first remedy for which is to get them up again, by relieving the rolls at the binding ends, and thus allowing the other ends to come together and equalize matters. A readjustment must then be made, and a thorough lubrication and cooling of the bearings effected. This trouble will be rare if the oil-wells are well supplied with clean oil, free from grit. Choking spouts are to be guarded against if the wheat or weather is specially damp. Exhausting must be maintained at the highest efficiency. Breaking belts are a feature of roll-driving requiring immediate and rapid attention and repair. They usually "go" at the joint, as the great power transmitted means heavy pulls upon them. It often happens that leather laces are constantly pulling out, whereas a common Harris fastener, if properly hammered or in exact line with the stress, will last a long time. In order to cope with sudden chokes, the feed spout should be fitted with handhole near floor-level

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above. The feed can then be allowed to pile up until this is reached, when an operative can "fetch" the stock away on to the floor until rolls are in full running.

A reference here, in connection with the break system, to Fig. 64 will be useful in following out the main breaking down of the wheat berry. The notes on the diagram make it self-explanatory.

Break System—Break Flour.—Much difference of opinion exists as to the making of break flour. Considering the matter impartially, the best policy is to make as little flour as possible whilst the break stock is in the presence of impure particles. The chances are against such stock or flour retaining its good qualities in colour, bloom, and strength. The first break flours, and the last, or bran flours, are the two poorest grades in the system, whilst the second and third rank tenth and fifth respectively. In the great majority of cases where the break flour is excessive, it comes from the breaking down of middlings from these second and third breaks. It will be found to contain fair all-round qualities, and it might be argued that, therefore, it need not occasion any comment or require any remedy to reduce its percentage. But it is really robbing the high-grade flours of some of their roller feeds and thus reducing the flour output of the patents grades. This high percentage of break flour will probably be of good strength, fair colour, and all-round baking qualities, but only because it contains so much good stock that the contaminating particles are reduced to a relatively small proportion and thus do not make themselves so obvious. It is against all the principles of modern gradual-reduction systems, with their elaborate grading and purification schemes, as it changes the graders and dusters into flour-dressers; they, in turn, delivering dusty and insufficient feeds to the purifiers.

Scratch Rolls and their Duties.—Scratch rolls are probably so called because their grooving is so fine that it comes under the heading of "scratches" rather than grooves. It is a cross between a break and a reduction roll; it is grooved like a fine break roll. It has differential speeds, like break rolls, and it runs at reduction roll speeds. It must be understood, in passing, that all roller-mills, whether break, scratch, or reduction, are similar in frame and general mechanical construction. The scratch stock is reduction stock with bran snips attached, and the duty of these rolls is to remove the snips from what would otherwise be pure semolina (see break

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plant flow-sheets). If the break rolls are kept from a severe treatment of break stock, a certain amount of "scratch" material is bound to be passed by the scalpers. This consists of large particles of semolina with the outer portions of the wheat berry still adhering. These are the outer layers of the endosperm, which will include the gluten and strength of the grain. This must be preserved for reduction into strong flour, but must be made to part with all other matter before being thus treated. The purifier tails this stock away as impure because it cannot purify and render it fit for the final grinding into flour. The scratch rolls, with their fine groovings, are designed for the delicate work of treating this material. Being like an extremely fine break-roll, they can, if the pressure is very carefully and exactly adjusted, do this work efficiently and with a minimum of powdering, sending the semolina back for repurification, but slightly reduced in size of particles.

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CHAPTER XIX

SCALPING AND GRADING

THE process of scalping consists of a series of sifting or grading operations—performed either by sifters or by pneumatics—upon the particles of endosperm released by the cutting edges of the break-roll corrugations. It aims at a preliminary sorting, of the various-sized particles released by the breaks, into several groups, irrespective of purity, and is the first of an elaborate grading series carried out by the chop machines and purifiers. Scalping must be performed with the minimum of friction and abrasion of good stock, as it is in the presence of impure particles and discolouring matter, such as bran and bran-powder, and depends upon its final separation from them, in the purifiers, by maintaining its difference in size and weight. The oldest machine employed for scalping is the round reel. It consists of a reel of silk or other sifting medium set at an angle with the horizontal, and rotated slowly on a central spindle. It is enclosed in a wood frame, with removable wood and canvas shutters at sides, for inspection, and with a single or double worm conveyor beneath to collect the stock as it is dressed through. Although at first sight the round reel seems gentle in its treatment of the stock, yet in reality it is too haphazard. It tumbles the stock about and retains it too long before dressing through, and thus tends to powder and abrade it. The round reel has two faults: (1) Its efficiency is restricted to one-sixth of the available area; and (2) the dressing or grading portion is crowded with the bulk of the stock. Concentrated at the one spot, the weight of feed is bound to sag and bulge the cover. Plain reels, as a rule, take more power than any of the later and more popular machines used as scalpers. Fig. 72 gives the action set up and explains itself. The first scalper improvement was effected by the introduction of the many-sided reel, having from six to twelve sides. The flat surfaces

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presented a better dressing face to the stock, catching it at a more efficient angle, see Fig. 73.

Next came the interelevator reel. This was made either circular or many-sided; but the special feature from which it received its name, was the addition of long internal bars or "buckets," attached to the cylinder and revolving with it. These bars constantly passing through the feed layers at the bottom of reel, carried or elevated some of the stock, until, coming to the highest point of the reel's rotation, it fell away on to the cover and thus helped to utilize about

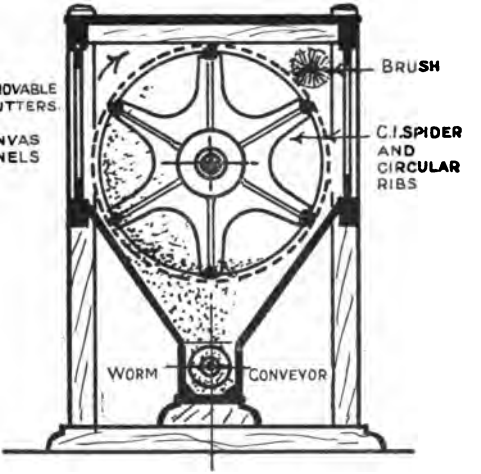

FIG. 72.—ROUND REEL.

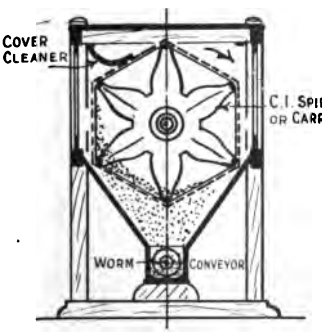

FIG. 73.—HEXAGONAL REEL SCALPER.

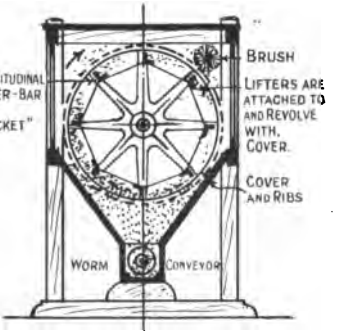

FIG. 74.—REEL INTERELEVATOR SCALPER.

one-third of the whole, as Fig. 74. The centrifugal is sometimes used as a scalper. It is a reel, within which are rapidly-revolving

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beaters, which pick up the stock and fling it against the inner circumference. It is objected to, by many millers, as a scalper, on the score that it is too violent for this duty; but although the beaters throw the particles of stock forward, they strike the cover obliquely. The effect of the throw is more like sand flung from a spade across the road, than sand flung squarely at a vertical riddle, see Fig. 75. It is not an ideal scalper. The centrifugal is essentially a flour-dresser, treating pure stock, where violence is not an objection. The *plane* sifting surface is the best for scalping operations. "It does not abrade but gently persuades," the stock to dress through. The common "dicky" or reciprocating sifter is the crudest form in use. The better type is the sieve on the hand-sieve principle, the rotary sieve scalper, and the plansifter being included. The rotary sieve is simply made, and easily accessible. It consists of a rectangular box, containing one or more sieves, and is rotated by a counter-balanced eccentric disc. It is slung, by leather straps usually, to a frame, and free movement is thus allowed. The travel of stock is accomplished by inclining the sieve covers towards the tail end. This machine is similar to the rotary grader in the wheat-cleaning section. The plansifter is used as a combined scalper, duster, and grader in many cases. It is best used as a scalper, except on the last break stock (bran-dusting), where large, soft, and sometimes damp material is being treated. Centrifugals are often used here. Plansifters of, say, four or five sieves would be much more appreciated here than those embodying ten or

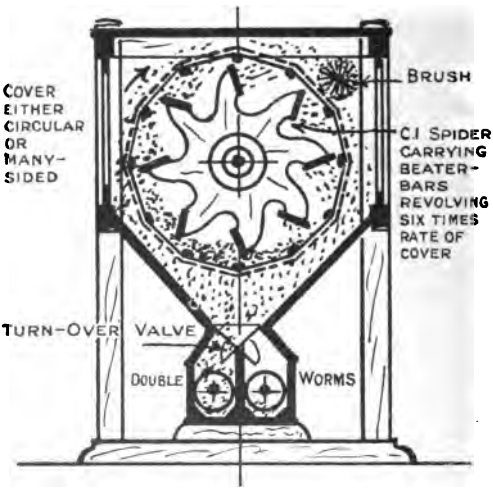

FIG. 75.—CENTRIFUGAL.

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twelve. A quaint description has been given of it by a miller. He stated that it was "a mechanically operated compound *hand*-sieve." This system lends itself to very gentle treatment of stock, and the arrangement of sieves admits of a great variety of combinations in scalping and grading. Another type of scalper, which is coming into use again in an improved form after many years of oblivion, is the gravity sieve separator. It is used either as a separate machine, or incorporated in break roll hoppers, in order to scalp the wheat particles as they are released from the roll grooves. It consists of a stationary sieve, usually of wire, set in an enclosed frame at a suitable angle to ensure the travel of stock continuously without the aid of reciprocation. The last section of the sieve is sometimes clothed coarse to obtain a "cut-off" separation. The feed is usually controlled and spread in the separate machines by a plain feed-roll and gate, and the sieve being kept clear by travelling brushes operating both above and beneath the sieve. An exhaust is applied at the upper end of the sieve. Removable canvas shutters on the front render inspection easy. Two or three delivery spouts are provided—"throughs," "cut-offs," and "overtails," see Fig. 76. The latest development of the scalping system is the cyclo-pneumatic scalper. It is evidence of the growing use of air currents in dividing up the many milling products efficiently and economically and with the minimum of flour

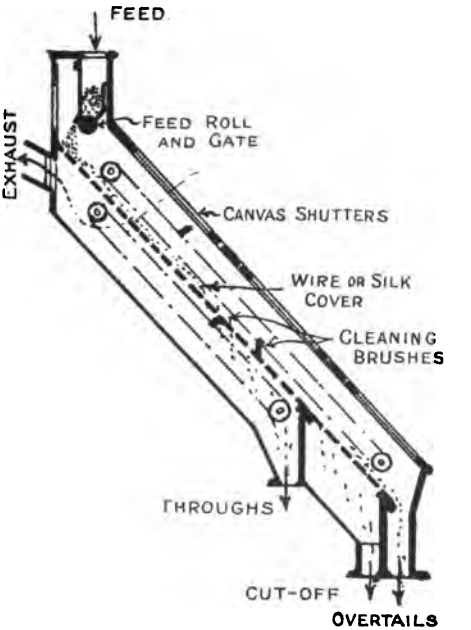

FIG. 76.—"BANBURY" GRAVITY SIEVE SEPARATOR (MESSRS. SAMUELSON'S).

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making. Although the various makes differ in detail, yet they embody the same ideas. It might almost be termed preliminary purification. Aspiration of stock, properly applied and regulated, causes little or no abrasion of the particles. In actual working it is not altogether practicable to depend upon air-currents only, in scalping and grading. Pneumatics and sifters are usually combined. In order to keep the air used for this purpose as clean as possible, a machine has been designed termed a "cyclo-pneumatic" scalper, in which the air-current circulates continuously. The principle involved is the familiar one of a thin sheet of material through which an air-current is drawn. The break stock is fed down the spout running through the centre of fan, and is deposited on to the revolving disc. This immediately flings it out in a circular spray, round the inside of the hood. The self-contained fan draws a current of air through this, lifting away the lighter material in the form of flour, dunst, fine midds, beeswing, and bran flakes. Material too heavy for the fan to lift will be deposited in hopper and spouted away. This will consist mainly of broken wheat, semolina, and coarse midds. When the lighter material has been drawn through the fan, it is carried by the exhaust air to the expansion chamber, and a further division takes place. The current, losing its force, deposits the greater part of its burden, and carries only the light break flour and stive into the cyclone, and there finally deposits it in the cone. The cyclone, being part of the machine, discharges its exhaust air as a supply to the fan, and thus completes the air-cycle, it being drawn through fresh stock, see Fig. 77 (Messrs. Robinson's machine). Messrs. Samuelsons make a somewhat similar machine. The

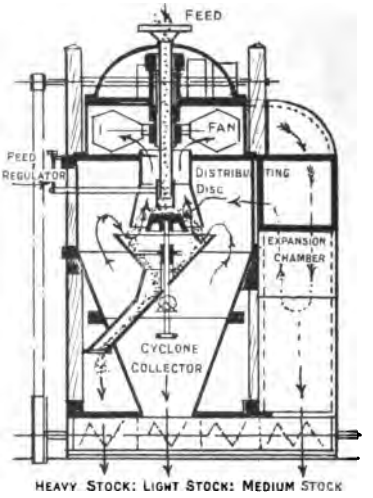

FIG. 77.—ROBINSON'S CYCLO-PNEUMATIC SEPARATOR.

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materials graded upon this separator are then further sized upon sifters or plansifters. Light stocks are divided into flour and dunst, fine midds and offals. Heavy stocks are separated into broken wheat for following breaks, and semolina and coarse middlings are sent to further dusting sieves for purifiers. With the exception of the I break, all the breaks depend upon the scalpers for their feeds. Their work can be severely handicapped by inefficient dressing and grading surfaces—which imperfectly separate the stock released from the berry, and send a percentage on to the following roll to be degraded and reduced. Any type of scalper should be able to " finish " its feed " clean " at each step, so as to give sharp free stock as overtails to rolls and throughs to chop and purifier systems. The covers employed should be of metal for preference, owing to the severe wear. Woven wire sheets are made of iron, steel, brass, phosphor-bronze, etc., perforated sheets of zinc, steel, iron, and copper, etc. Each have their special advantages. For all-round excellence upon sharp break stock a perfectly perforated zinc plate is first. It does not sweat or rust in the presence of humidity, even if its life is not quite so long as steel. It does not clog, or present the uneven surface of woven wire, or fray and wear like silk and grit-gauze. Particulars of these covers are given in separate list.

Operatives usually give too scanty attention to this section of the milling process, and often the purification section, being very carefully tended, fails to give first-class results, because the scalpers are muddling the products. Operatives' duties include: (1) Careful and constant adjustment of the feeds to all scalpers and chop machines, ensuring a wide-spread stream for a thorough separation of the crude varieties; (2) avoid " bunching," and travel stock through as fast as possible, consistent with gentle treatment and minimum friction; (3) apply and regulate exhaust, humidity being a danger here as on the high-class patent flour dressers; (4) report any irregular or badly broken feeds, so that matters receive attention without delay. A relation exists between the size of grooves on the break rolls and the size of meshes on the scalper covers, because a certain size of groove will release a corresponding size of endosperm particle, and the meshes of the scalper cover must be made large enough to dress this through, as it must not be allowed to tail over to the next break. Again, in this connection, scalper covers are

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bound up with the purifier's covers, because they determine the size of stock passing to the purifiers *viâ* the chop, and the covers of these latter machines must be made to suit. This goes on all through the mill.

A brief list of scalping machines is—

(1) **Reels.**—Either round, hexagonal, octagonal, or many-sided, or interelevator.

(2) Centrifugals.

(3) Rotary or reciprocating sifters, single or double, plain or aspirated.

(4) Plansifters, aspirated.

(5) Pneumatic scalpers, or sorters.

(6) Roll scalpers, and gravity sieve separators.

The surfaces of each type in relation to the mill's capacity cannot always be determined with any uniformity, a standard being rather impossible owing to the great diversity of methods, treatment, and stock. Single sieves as scalpers usually require two square feet per sack of plant capacity. Single sieves simply separate, while double sieves separate and grade.

All reels and centrifugals are measured in length by " sheets" or metres (approximately 40 inches), being so made to suit the width of the Swiss silks of one metre.

Fourth Break or Bran Stock.—The treatment of IV break stock must be conducted on very exact lines. It consists of bran, from large flakes to fine powder and shredded skins. Mixed with these will be a percentage of fine flour stock and dunst. Very little of the grist will be free or granular. The first consideration will be to get the bran safely away and sacked off. Then the jumble of dunst, flour, fibre, and fluffy material, of much the same size and weight must be treated. The shredded bran and powdered cut-up stock will tail over to the bran-duster and insist upon some sort of treatment. Because the stock is soft and contains but little stock of a friable nature likely to be damaged by rather severe treatment, it is common practice to employ the centrifugal as the bran-duster, taking from the IV break rolls. It is speeded 20 per cent. faster than when used for ordinary dressing purposes, in order to separate the soft and clinging stock efficiently. The cleaned or dusted bran, tailing over from this machine, is sent either direct to sack or through a pair of flattening rolls. Modern practice tends to clean and dust the bran too closely. Bran itself, absolutely devoid of flour or stock contamination, contains but a small amount of nourishment or

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nutriment, and is of but small value as a food stuff for cattle. In former days, and even now in country mills, the miller did not trouble to clean the bran very finely, with the result that the flour clinging to it, went to the bran sack, enhancing the feeding qualities of the bran and fetching higher prices. In the large modern mills this has been changed. By conditioning, and by very exact working of the break rolls and scalpers, the wheat skins are kept reasonably whole, whilst every particle of endosperm is cleaned off and graded away to swell the flour percentage. The safest treatment is that which whitens the offals, but keeps the low-grade flour a saleable fair colour and condition. Although offals containing fine bran and bran shreds can be found lower down the mill, yet the only real commercial bran is removed at this point. Any defects in the size and condition of bran from the B.D. such as marks of corrugations, or curling, should be at once remedied upon the breaks. The machine taking the throughs of the B.D. is called the Bran Meal Centrifugal, this type of dresser being also employed here. The cover should be fairly fine in order to ensure a fair colour of flour " dusted " away. This will be the bran flour. Overtails and tail-sheets will send stock for further treatment upon purifiers and reductions usually. Figs. 64, 85, 86, 87 can be referred to.

Grading.—Grading, or grouping stock for purification system following, demands the most careful consideration in order to give the various purifiers the most consistent and useful feeds. In large mills a great deal of division and sub-division takes place, and the best results in flour percentage and quality can be expected. Because the more uniform in size the particles of feed to any purifier, the more perfect will be its work in providing consistent feeds to the reduction rolls. These latter can be thus finely adjusted for close work and more complete reduction of stocks into flour, with a low range of variation of particle sizes. The maximum of flour will be made at the earliest possible moment, and the bugbear of long systems—repeated rolling and retreatment of stock, to its detriment in strength, colour, and general good qualities —will be avoided. In working the grading system, the following conditions must be borne in mind. The stock is sharp, friable, and in the presence of impurities (bran particles), which must be treated gently whilst grading, so as to avoid abrasion, and to maintain their distinct difference in size and weight. The extremes of size and weight must be tailed or

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dressed away. Break flour will be dressed through, termed "dusting," and the largest particles, containing some bran snips, will be dispatched to a purifier, which will tail these over for treatment upon "scratch" rolls. In large systems the groupings of stock are generally divided thus: (1) Coarse semolina; (2) medium semolina; (3) fine semolina; (4) coarse middlings; (5) coarse middlings "re"; (6) fine middlings; (7) fine middlings "re"; (8) dunst; (9) "tins" or "trays." There are also Bran Meal stocks which often receive separate purification treatment. The most noticeable results of these elaborate classifications are, to almost eliminate the objectionable repurification of rolled stock, so often carried out in small and short systems. It is the real economy peculiar to large installations, and one of the best arguments in pushing these to the greatest capacity within working limits. It will be seen that we have a wide range of sizes before us for treatment—from eighteen to flour numbers. If rolls and scalpers are doing efficient work, it will be by no means difficult to obtain these, as the stocks are naturally in a sharp, free condition. Figs. 64, 83, 84, 86 will be a help.

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CHAPTER XX

SIFTERS AND PLANSIFTERS

SIFTERS are usually more or less imperfect copies of the original hand sieve or riddle. The reciprocating sieves, with their sharp jogging action, are the oldest forms of sifters. They really " shovel " the stock down the inclined surface so that the smallest particles, sinking to the bottom of the feed covering, are dressed through. Tappet gears are always necessary to further assist this action and keep the meshes clear. There is a limit to these machines as to size. As they developed in size and capacity it was found that they communicated their vibrations to the building and became a nuisance and a danger. In their place came the rotary sifters, which consist of a sieve-box, containing one or more sieves, slung from a frame by rods and straps and having a fixed rotary motion imparted by a vertical spindle and crank-disc, counterbalanced to take the " throw " of the box. The sieve has a fall of about $\frac{3}{4}$-inch per foot. Too violent an action will bounce the stock away to tailings.

The most interesting of all sifters is the plansifter. After many vicissitudes, in England especially, it has, with the substantial improvements made, gained a place for itself. As its name implies, it sifts the stock upon a plane, or perfectly horizontal surface, and depends upon inertia and centrifugal force alone to propel the stock. Gravity does not come into play as in the ordinary inclined sieve. On the Continent and in America it is practically the only grading and dressing medium employed in some mills. Yet in England up to quite recent date comparatively few mills used them. Many reasons have been given for this, but in America and in parts of Europe the climate is generally drier and the atmosphere clearer. The wheats are of a fairly uniform condition,

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giving plenty of hard granular stock. In England we have prolonged spells of wet and foggy weather, when the air is heavy with moisture, when spouts and machines are sweating rather badly, and when the stock refuses to dress through freely. The world's wheat, from which we have to select our grinding mixtures, is composed of a large percentage of the softer classes of grain, yielding soft stock. We are forced to use these for the sake of colour, and we never get beautiful free granular stock like the American miller. These details are certainly factors against which the plansifter must fight. That this class of machine is steadily, if slowly, making headway in spite of all these obstacles in its path, is surely to the credit of manufacturers, who have steadily sought to improve it by careful and painstaking attention to all its details.

Vibration used to be one of the objections to the plansifter. The latest balancing improvements, combined with good floors and walls, has greatly mitigated this trouble. There are several reasons for this fault in plansifters. Any body working eccentrically is bound to impart a " throw " to its attachments unless exactly balanced. Directly the machine becomes worn in either bearings or eccentrics, all initial faults become accentuated. The standard type of plansifter and the one most widely used, consists of two rectangular nests of sieves placed side by side, fixed and carried together by c.i. frame arms. These arms are supported upon four rocking rods working in ball and socket bearings bolted to the floor. This arrangement allows the whole machine to swing out of centre in any direction, and it is thus enabled to receive the eccentric motion easily and smoothly. The driving is obtained either from a central vertical shaft, which in some makes is driven direct, with pulley and quarter-twist drive beneath the floor, and in others, notably that by Messrs. Robinson's of Rochdale, from a double-crank drive with two vertical spindles receiving motion from double-twist belts, worked over guide pulleys from the horizontal countershaft on floor, see Fig. 80. The vertical spindles are supported in a widespread c.i. pedestal, and work the counterbalanced eccentric discs, set in the main frame arms. The whole eccentric drive and counterbalance being thus in the centre of gravity of the two nests of sieves, the " throw " or vibration, so objectionable in the early types of plansifters, is obviated. In some makes, a good feature in the counterbalanced discs

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is that while the weights are carefully tested and balanced during construction, provision is made for slight additional adjustment, to rectify any variation which may occur in the balance of machine after some running, when it has finally settled to its work.

From the author's observations of plansifters and their

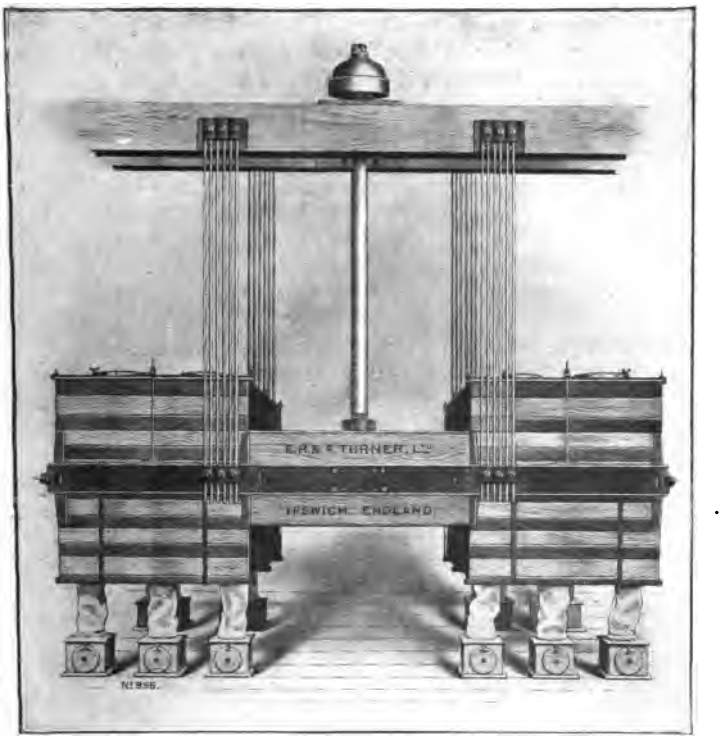

FIG. 77A.—THE TURNER FREE-SWINGING SELF-BALANCING PLANSIFTER.

working, the most perfect running action giving the best dressing results because of freedom from "jumping" is obtained from the "self-contained" machine. By this is meant the plansifter, which has all its attachments and drives on one floor. With c.i. standards, from which the rods are hung or with rocking rods

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directly supporting the boxes from the floor castings with ball and socket bearings, with drives and all other moving parts supported from the same floor, the whole shock can be taken by it and attention paid especially to strengthening it if necessary. A further development of the plansifter drive is the free-swinging self-balancing type. A swinging balance-weight revolves on a vertical free central spindle and imparts a very easy motion to the sieve nests. Both drive and sieves are supported from ceiling.

The large number of sieves available in plansifters and the fact that each sieve can, if required, be divided into 2, 3, or 4 sections, makes a large number of gradings possible on one machine. An efficient system of brushing and of ventilation is essential in order that the tendency to clog and sweat, so fatal to efficient work upon these machines, may be kept in check. The system of stock propulsion over the sieve is interesting and novel. The feed being on a perfectly horizontal plane requires some assistance to enable it to travel towards the delivery or overtail. On entering the sieve, the stock is sorted in such a manner by the circular eddying motion imparted by the throw of the machine, that the finer, heavier particles gravitate to the underside of the stream and come into contact with the cover, the coarse, light particles remaining on the top of the stream. At every swirl or circle made by the feed, it is caught by the slats, fixed on, and projecting from, either side of the sieve frame. These slats do not quite reach the silk or grit-gauze cover. A gradual forward movement of the whole stream is thus set up, whilst the finer, valuable stock escapes abrasion, the top stock acting as the propelling medium. The overtails of the sieve pass through a coarse ¼-inch mesh placed over the outlet to retain the brush-cleaners. The latter are hinged to the long division slot, and travel beneath the cover, being supported upon the sieve trays. To ensure the continuous travel of these brushes, the circling action and throw of the sieve-frame is again brought into use, see Fig. 78. In the repeated jogging which these brushes receive, the bottom bristles are constantly thrusting off from the tray and move the brush along beneath the cover, the soft bristles dragging the meshes free of stock. It travels down one side of the sieve, round the end, and back along the other side, and swing round the other end to its starting-point. There are, of course, many ways in which the sieves and trays can be arranged in a plansifter; but the duties

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required of it must be exactly known before arranging. There are approved systems for the machine, as grader, scalper, or dresser, and they must not be confused. This applies both to the order of sieves and trays, and to the flow of the stock through the machine. Broadly, as a scalper, it should have a wire sieve and silk or grit-gauze sieve, and a tray placed in rotation. As a grader or dresser, it should have a sieve of either grit-gauze, wire, or silk, and a tray beneath. In any of these, a moderate scheme of this duplication would appeal to most millers, especially those dealing with scalper stock only. Fig. 79 gives one arrangement as a grader.

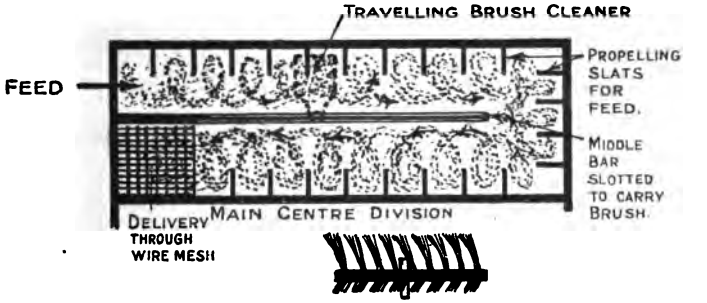

FIG. 78.—PLANSIFTER STOCK TRAVEL.

The scheme shows a set of twelve separate sieves "nested" together. Each one is of course removable, see construction of machine, Fig. 80. A difficulty experienced in mills adopting plansifters is that the usual operative, even with a good knowledge of fixing covers on sifters and centrifugals, does not make a success of attaching the sieve covers at first. Having no natural "bias" to enable the stock to gravitate to the delivery end of sieve, but depending upon the peculiarly sensitive "warping" along from one propelling slat to another, the slightest twist or straining in the cover, rendering it uneven, has its effect upon the efficiency of the dressing action. This trouble automatically adjusts itself as the operative becomes an expert in working plansifters.

The following is a brief list of the special features of this machine.

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Advantages.

(1) Smali power required per sack.

(2) Capable of a wide variety of separations or groupings with good results if not carried to excess.

(3) Gentle treatment of valuable, friable stock, such as scalpers and graders have to treat, thereby making a minimum of break flour.

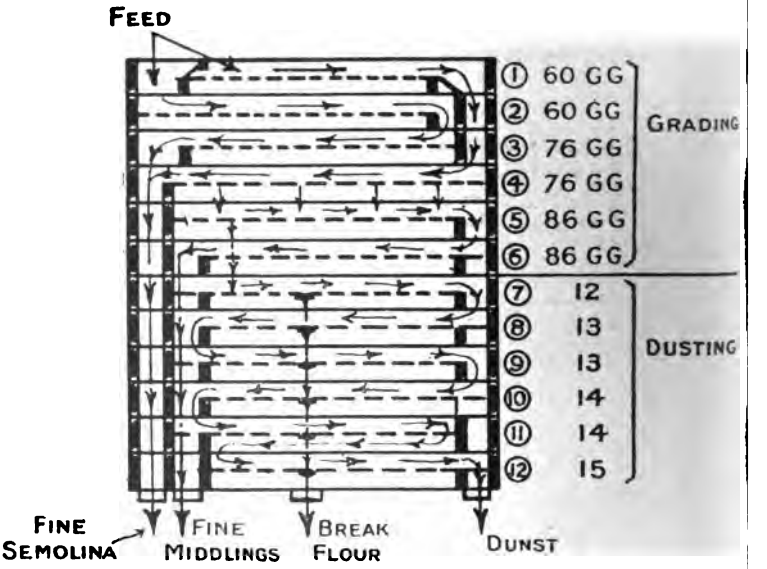

FIG. 79.—PLANSIFTER AS GRADER.

(4) Economy of space if planned in sets to advantage.

(5) Does excellent work upon sharp free stock.

The disadvantages of the plansifter are gradually being eliminated as far as lies with the machine. In the main, the troubles experienced can be summed up thus: (1) Shows a tendency to overtail rather freely when treating the softest stock on the last few reductions, more especially upon damp, humid days; (2) Susceptible to drop in speed; (3) Vibration. This can be reduced to an almost negligible quantity if specially strong attachments are provided and the floors strongly

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braced and cross-boarded, beneath the machines. Careful arrangements of plansifters in pairs, so that the action and slight sway of one is neutralized by its fellow, has been found a material benefit.

It is necessary to employ painstaking operatives on this section to ensure perfect running. He should see that the

FIG. 80.—ROBINSON'S PLANSIFTER.

machine is correctly balanced, that the sieves are all quite securely clamped together before starting up. He should be able to detect damaged or defective sieves by periodic examination of all stocks and must change same with ease and rapidity. In arranging the machines, accessibility and ample floor space round each should be studied. Thorough exhaust is also an important item.

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A feature becoming a first essential as plansifters obtain a wider use, is that of a brushing system which can be relied upon to work efficiently under all conditions. On the softer stocks it means just the difference between success and failure.

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CHAPTER XXI

FLOW SHEET DESIGN

"FLOW-SHEETS," or diagrams, illustrating the course through which any material travels whilst undergoing treatment in manufacture, are usually associated in the flour-milling processes, with the actual flouring plant only. The term should, however, be used and applied in a much wider sense to all departments.

Care in "block-spacing" the outline of the main machines on the space at their disposal before filling in the flow lines of the stock will keep the figures clear. It is only necessary to indicate the barest outlines. In practice it is best to put the machines in black ink, and the flow lines in red ink. (Of course, in the illustrations here, it is only possible to use black printing throughout). Two systems are followed in flowing the intake and grain-handling plants: one is to place machines in their relative positions and indicate the actual course of the grain by inserting the elevators; the other is to ignore actual conditions and construct the figure in the simplest possible way, giving the travel of the grain from one machine to another, in the most direct manner, irrespective of vertical or horizontal travel. This latter method is always followed in the flour-mill flow-sheets.

Figs. 21, 22 of the intake and storage plant are a mixture of the two systems and the composite method often adopted at this stage. In the wheat cleaning, washing, and conditioning plants, and most of all in the mill proper, the only clear way is to disregard relative positions of machines and direction of flow of stocks, either vertically or horizontally, and to devote one's self solely to the simplest form of line expression. Those to whom this class of milling drafting is unfamiliar are advised to study Figs. 42, 48, 83, 84, of the cleaning and milling plants respectively, and to copy these if possible. In this way the principle involved will be more thoroughly grasped, and can then be applied to ideas and schemes other than

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those given here. The skeleton or block flow-sheets, Figs. 81 and 82, emphasize the main masses into which each section of the several processes should be grouped.

In Fig. 21A of the intake plant, the main distinctive

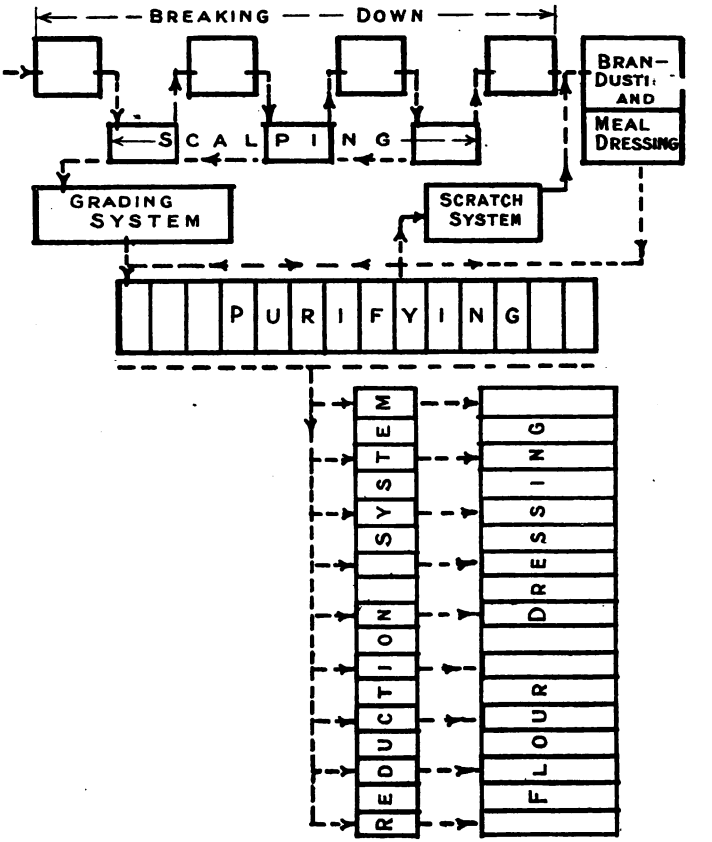

FIG. 81.—BLOCK FLOW—GRADUAL REDUCTION SYSTEM.

operations are indicated. Fig. 21 is the detailing of the same flow, and the relation to each can be traced, particular notice of the system of exhaust and turnover should be taken. Coming to the dry wheat-cleaning flows, Fig. 41 indicates the main sectional operations and their order. This

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should be studied with Fig. 42. Whilst many variations of planning may be made, the main lines will be adhered to in modern practice. Fig. 47 of the washing and conditioning plant, block flow, and Fig. 48 of the elaborated diagram of

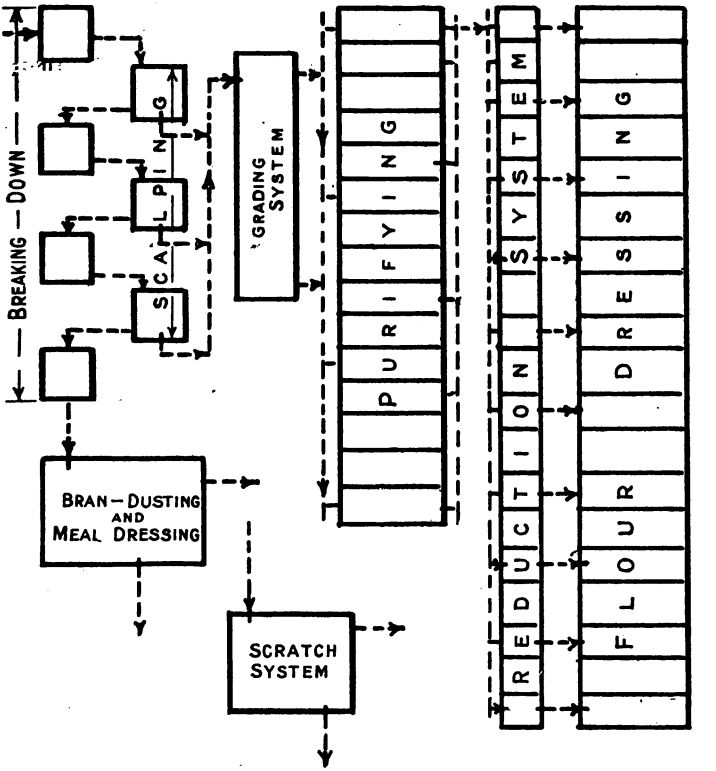

FIG. 82.—ALTERNATIVE BLOCK FLOW—GRADUAL REDUCTION SYSTEM.

same, must in like manner be bracketed together. In the mill, Fig. 64, already referred to, can first be studied with the fellow block flow, Fig. 81. They both embody the same ideas and principles. The 5-sack plant flow-sheet, Fig. 83, is a detailed scheme on the lines of Fig. 81; and the 20-sack flow, Fig. 84, is on the lines of Fig. 82. The latter arrangement is perhaps

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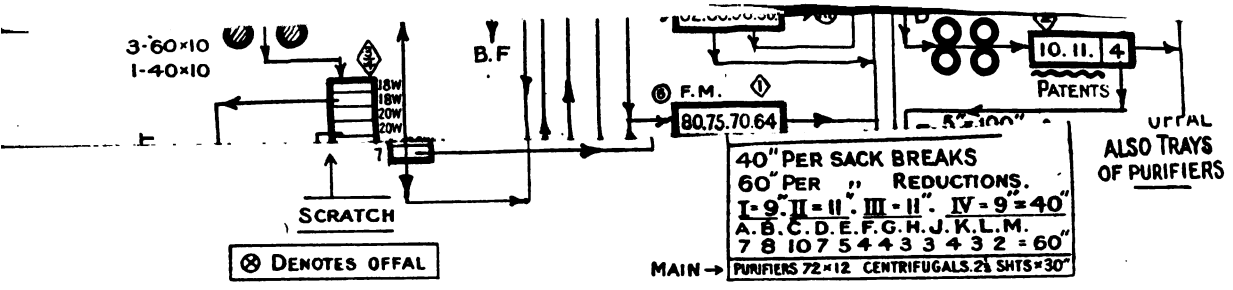

FIG. 84 —20-SACK FLOW-SHEET.

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most popular now. Figs. 85, 86, 87 are break systems the three distinctive types in use.

To the novice, and even to those who are quite at home a mill, the flouring-plant flow-sheet often appears a comp cated and rather "fearful and wonderful" thing, evolv

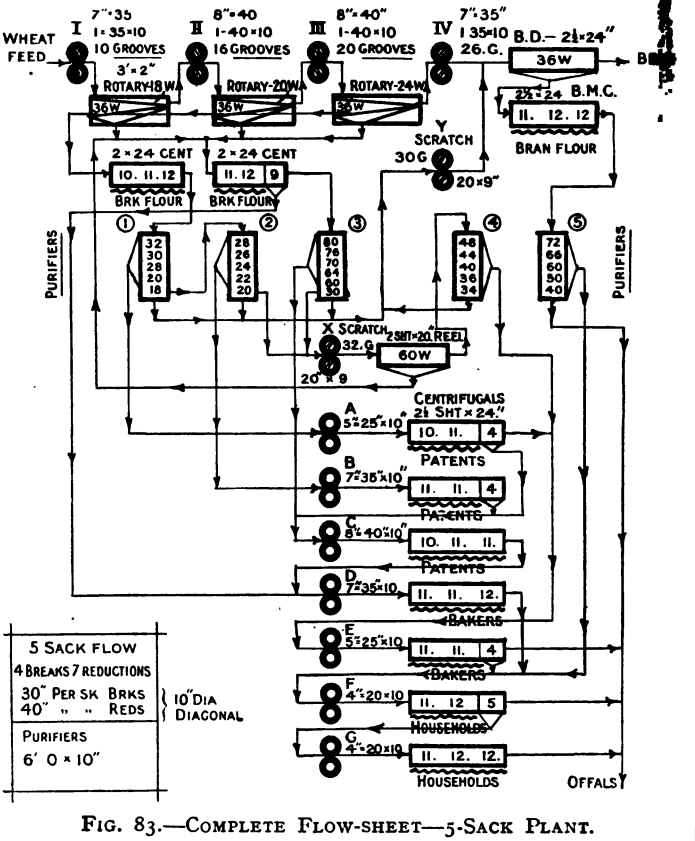

FIG. 83.—COMPLETE FLOW-SHEET—5-SACK PLANT.

from, and understood by, the brain of that learned being, the milling expert only. To ordinary mortals it is often a closed and sealed book, whose only use is in enabling the operative to trace the stock from one machine to another in the event of a breakdown or alteration to existing scheme;

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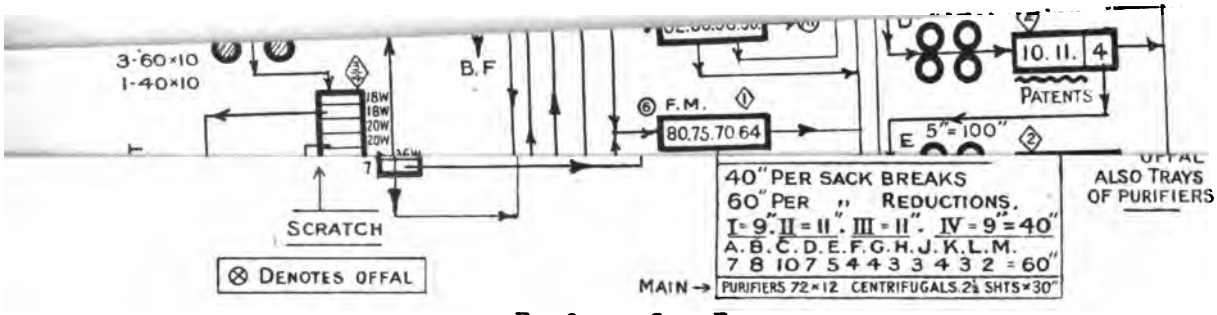

FIG. 84 —20-SACK FLOW-SHEET.

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a kind of "drain-plan" to be a guide in case of stoppages. But, correctly worked out, a flow-sheet is a scientific scheme, based upon well-tried formulæ and capable of close reasoning. To be able to originate a good flow, or even to diagnose an existing one, so as to make a correct analysis of all its sections, is to prove that one has a pretty thorough knowledge of milling. As there are a dozen different ways of working out a mathematical problem, each of which may be quite in order, so the schemes of flour-making differ in detail, though not in principle or final results. If a collection of all the flow-sheets throughout this country could be made (what a time it would be!) there would be no two exactly alike. How then, it may be asked, is it possible to

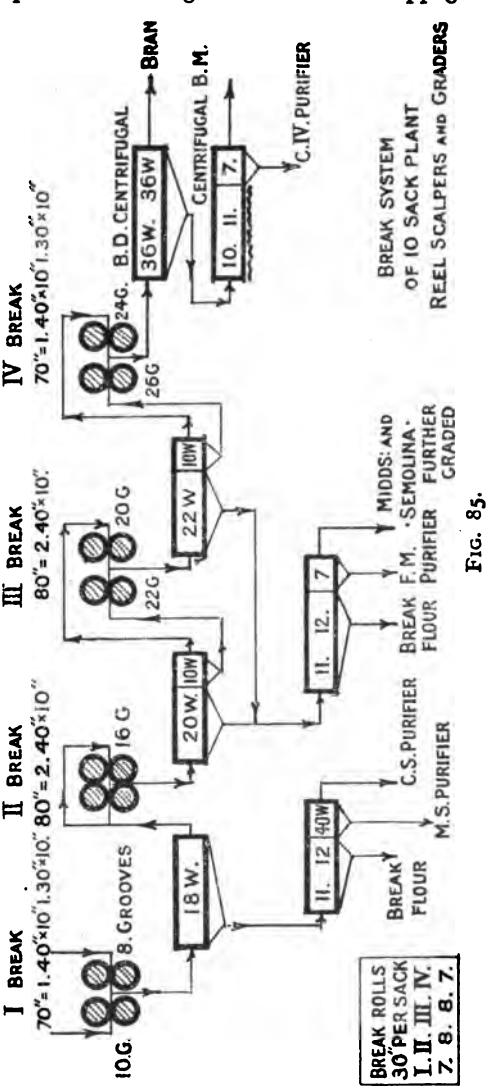

FIG. 85.

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believe that the great majority are based upon sound scientific

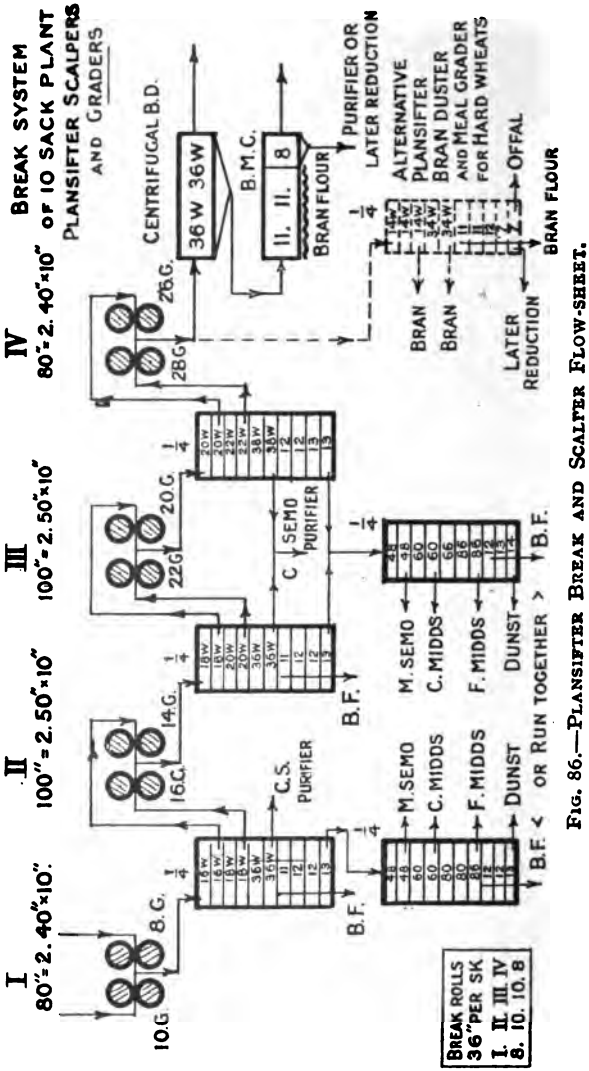

FIG. 86.—PLANSIFTER BREAK AND SCALPER FLOW-SHEET.

principles? The answer lies in the fact that while it is possible to divert a flow, or to alter the treatment of a certain

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stock, a compensating correction must be made later in the system if the best principles are not transgressed and no wastage occurs later. In a mill, each machine in size, amount, and quality of stock produced directly affects all the following ones. When, therefore, a scheme of groovings, covers, and

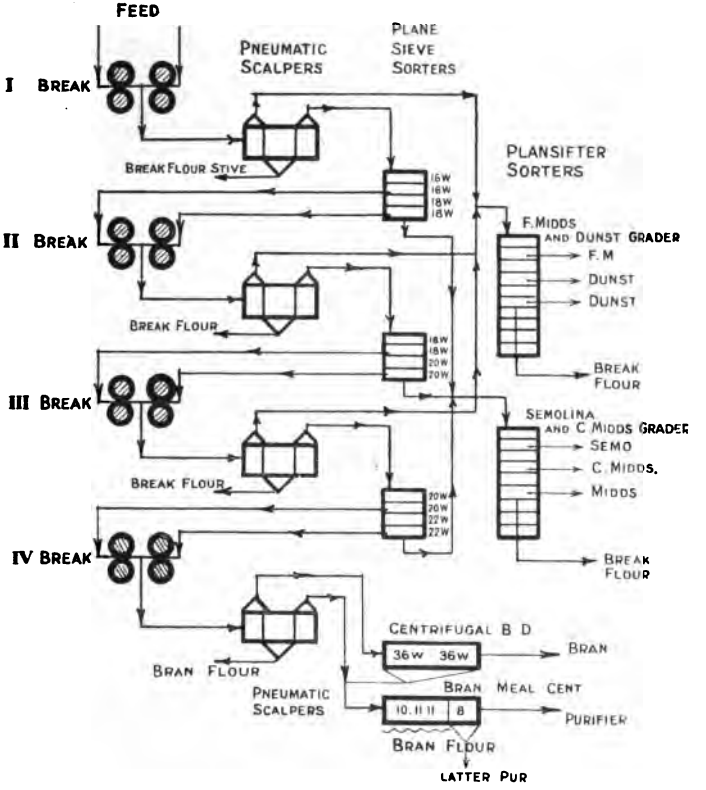

FIG. 87.—PNEUMATIC BREAK AND SCALPER FLOW-SHEET.

machines in order has been devised to give certain results, the lines laid down must be adhered to if the first principles followed were correct.

Before a flow-sheet can be planned, even in skeleton, it is necessary to ascertain the following particulars, basing it upon them, because naturally, local conditions and trade requirements as to flours and offals will have a strong bearing

upon the matter. Rules and requirements can be considered in the following order:—

(1) Size of plant in sacks per hour (of flour output).

(2) Main grades and nationalities of wheats to be ground.

(3) System of cleaning and conditioning, as determining the feed to the mill, especially governing the moisture percentage and its effect upon roll groovings, surfaces, and covers.

(4) System preferred, long, short, or severe. Method of scalping and grading, bearing upon grouping for purification.

(5) Flour or flours required; quality and number of grades. What class of trade and district mainly catered for. If high-class patents a feature.

(6) Offal and grades of offal; local demands.

(7) Location and general working and staffing of mill, distribution of products, type of power motor.

The essentials in planning can be summed up as:—

(1) A steady and evenly distributed set of stocks or groupings, of uniform grading as to size and quality, and suited to each machine's capacity, avoiding over-crowded or bare covers and surfaces.

(2) Percentages and grades to be maintained.

(3) No confusion of sorted stock, or over-treated and wasted material.

(4) A forward movement of all stock in preference to any return or re-treatment.

(5) The scheme to be self-contained and automatic, but adapted to variation at any required interval.

(6) Conveying stock to be avoided as much as possible.

(7) Offals well finished so as to maintain a good flour percentage.

To emphasize the main skeleton system followed in this country, the key-plan of a flow-sheet is attached, see Fig. 82. Here the main operations are shown *en bloc*, and will serve as a frame upon which to hang the actual and, of course, more involved flow-sheet following, Fig. 84. In order to concentrate information, given also under the sectional headings of the process, all details of surface, and other averages, have been added to this, Fig. 84, and these again will be found useful as a reference whilst studying flows. A medium capacity plant has been indicated, but of only average length in reduction section.

The 5-sack and the 20-sack plants respectively have been "flowed" on the main lines of practice. In some plants

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much more elaboration of side issues will be made, but this treatise does not aim at advanced matter, therefore the flows have been simplified as much as possible, also the actual number of machines has not been shown for the same reason. The number in the triangle ◇2◇ indicates these in each case. It is always possible to subdivide or to especially treat any particular stock. The 5-sack plant is shown using rotary sieves for the scalping-reels and centrifugals for the grading and bran-dusting, moderate-sized sieve purifiers, and centrifugals for the flour dressing. Moderate surfaces only have been employed. Students can adapt the more up-to-date break plants given separately, and modify the reductions and dressing scheme somewhat to suit. This will be found useful practice.

In the 20-sack plant the lengths of surface given (40 inches for breaks, and 60 inches for reduction) are well up to modern practice for that size of plant. The author has chosen plansifters for the scalping, grading, and preliminary stages of flour-dressing where the stock is still free and granular. The main dressing, however, has been accomplished upon centrifugals. All rolls shown are of the diagonal 4-roller type, 10 inches diameter. The lengths have been arranged to suit the scheme as closely as possible. The special feature to be noted is the finely graduated division or grouping of stock on the plansifters for the purifiers' feed. This is only possible with this type of grader.

Mill Working.—In order to link up ideal flows with actual conditions and work and hindrances tending to upset the smooth operation of a mill, a short *résumé* of the latter will now be necessary.

Each machine is designed to take a certain amount and quality of feed, and this must be maintained as a standard, under normal conditions, if good and uniform work is to be possible. Too often millers are prone to put a "bit more feed on" and upset the scheme of things. Slight variations, due to a change in the condition of wheat or atmosphere, will occur, but these must be met by corresponding adjustments of the rolls and other machines.

Normal conditions in England are dull damp days, often steamy and humid within the mill. On such days the mill works heavily, machines and spouts becoming clogged. Unless great care is exercised in conditioning, the wheat will be too soft. The bran will, as in the case of badly conditioned wheat, bunch and hang up in the delivery hopper of the last

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break rolls, and will also prove very difficult to "finish" or "clean." That is, the meal and fine floury dust will persistently cling to the bran flakes and go to swell the offal and bran bags. All the rolls, especially the reductions, will require constant attention; because, on the latter, the soft and clinging stock will mean "ringing," "flaking," and uneven grinding. The dressing machines will be clogged and will need repeated brushing to ensure a moderate percentage of throughs (*i.e.* flour). All the offals will be too rich and white. This means reduced yields of flour.

A bright dry air, whether hot or cold, will cause the wheat and stock generally to become dry and free. The rolls will tend to make more fine bran, and more middlings than semolina. The purifiers, although somewhat dusty, will grade freely. The reductions will do good work, and the flour dressers will dress freely. The general flour yield will probably be higher.

If break-rolls are working badly, and cutting up the purifier stock severely, the break flour will be greatly increased in percentage, and many complications will ensue, the principal result will be that the amount of higher-priced patents and Baker's flours will be correspondingly reduced.

The miller must see that each unit of the system is doing its full share of work efficiently, otherwise the whole plan of manufacture, outlined by the flow-sheet, falls to pieces. A safe rule to follow is to arrange a system wherein the "offscourings" are not over-treated. No fixed standard for offals as to quantity and quality has come into force, but it can be taken for granted that most millers look with distrust upon offal full of rich floury stive and stock, and steadily try to avoid it by clean and close finishes. Gross variations of stock should not be permitted to go to one pair of rolls. First, because of size, and second because of obvious differences in quality, which are bound to be present. As far as possible the flow and plant must be so arranged that control over the products is easy and certain. Any variation desired, even with an unchanged wheat mixture, should be possible within reasonable limits. This especially applies to flour, where even in medium plants ten distinct runs are often necessary. The main stocks referred to as the residues of the milling system may be summed up as—

(1) Granular, gritty material with bran snips adhering. Must be treated upon scratch rolls, graded, dusted, and repurified, as it contains valuable stock.

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(2) Thick fibrous stock with small quantities of adhering flour stock from last breaks. Best to roll this once and dress on coarse wire cover.

(3) Light fibrous stock and beeswing, with flour particles present, from last reductions. Roll and dress to ensure the removal of any pure stock.

Other points to which the flow-sheet designer must pay attention are the following. Heavy middling must not be sent too far forward down the mill. Grades of stock once separated must not be brought together again, or damage and deterioration will certainly result. Heavy coarse stock must not be dusted upon a fine silk. To sum up: All material must be "placed" accurately with regard to size, quality, and quantity.

Stock Travel.—The angles at which stocks are spouted are of real importance, and well worth consideration when erecting or altering spouts. If the spout is too flat or has too many bends, the stock will be retarded, and chokes will occur; and if too steep, the impact will damage and powder it, besides forcing hand-hole covers off and being a general nuisance, causing waste and loss. The angle of repose for material falling from rest (from conveyors, machines, etc.) differs from that which is flung from the buckets of an elevator. Stock should slide in an unbroken stream. The ideal is often impossible owing to space and height available, but a knowledge of the correct angles will enable one to avoid glaring errors. Too flat an angle can often be remedied, in wood spouts, by lining them with sheet tin.

STOCK WEIGHTS AND ANGLES OF TRAVEL.

Material.	Pounds per cubic foot.	In wood spouts, from rest.	In sheet-tin-lined spouts, from rest.	In wood spouts from elevator.
Wheat . . .	48–50	35°–40°	30°–35°	25°
Whole meal . .	48	45°–50°	40°–45°	35°–40°
Semolina . . .	50	40°–45°	35°–40°	30°–35°
Middlings, dunst .	52	45°–50°	40°–45°	35°–40°
Fine sharps . .	30	55°–60°	50°–55°	45°–50°
Coarse sharps .	24–28	45°–50°	40°–45°	35°–40°
Bran, ordinary .	16	45°–50°	40°–45°	35°–40°
Bran, broad . .	10	45°–50°	40°–45°	35°–40°
Germ	20	45°–50°	40°–45°	35°–40°
Stive	10–15	70°–80°	65°–70°	55°–60°
Flour, average .	46–48 (56 lbs. per Bushel).	60°–65°	55°–60°	50°–55°

NOTE.—The weights refer to packed products.

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Flour Mill Arrangement.—The miller should have some definite scheme for planning his mill. The main idea followed is to have a central line of elevators delivering to right and

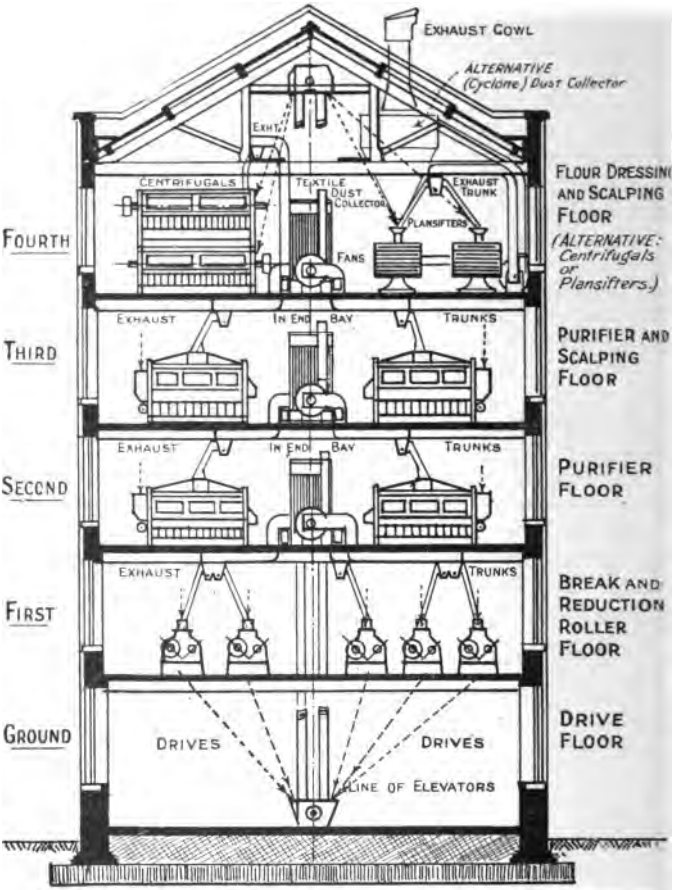

FIG. 88.—CROSS-SECTION FLOUR MILL.

left of the building. This economizes both space and building cost per sack. In moderate plants the roller mills are arranged on the first floor to right and left of the centre, and with both end bays clear. Clear working space should be left both

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between the rolls and along the walls. In large plants, the rolls will occupy two floors. If possible the first and second should be utilized, leaving the ground floor clear, except for elevator boots and main drives to first floor rolls. On the second and third floors, in Fig. 88, are shown the lines of purifiers. These should be placed so that the feed boxes are at the window end. Thus all feeds can be checked by daylight. The third floor, being usually only partly filled by the purifiers, serves also as a scalping and grading floor. The fourth or top floor is mainly used for the flour-dressing machines. These will be either of the centrifugal or the plan-sifter type. The former are often placed two-high for space economy. Fig. 88 shows these two types placed in the alternate halves for purposes of comparison. Greater space must be left round the plansifters for the purposes of sieve removal and clearance for the motion, than for the fixed frames of the centrifugals; but the capacity per square foot of the floor space is greater. Inspection platforms are placed upon the tie-beams of the roof trusses, so that the elevator-heads can be closely inspected and oiled. Two points govern the arrangement of machines in a flour mill. *First*, the main shafts should obtain good lengthy drives from the engine, and the drives from these to the machines should be at the best working angle, and clear of passages. *Second*, that the sequence of flow should be as closely followed as possible, using spouting wherever practicable in preference to worming. One feature of this figure will probably be commented on—the rather elaborate system of exhaust and of dust collecting. As already mentioned, the textile collector placed locally, is in favour; the fans delivering to it being close by and operating whole ranges of machines through main trunks. The mill should be light and airy, with ample head room and space to clean down. The window ledges should be provided with sample boxes, kept freshly supplied each shift. Details of the building, such as columns and joists, etc., and all driving gear and shaftings, have been purposely omitted as they do not enter into the scheme of machines, and would only render the figure confusing.

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CHAPTER XXII

PURIFICATION

PURIFICATION means the removal of branny, fibrous, or light stive material, liable to contaminate the resulting flour, from semolina and middlings. Also to finally group the stock in definite divisions most suitable for reductions. Both operations are performed by the application of (1) air currents, and (2) sifting, either separate or combined. The air currents weigh the stock, or separate by gravity. The sieves separate by size and shape. The large branny particles are tailed over; the light bran and beeswing is lifted and deposited on trays by air currents; the fine stive is carried still further and deposited in a special expansion chamber, leaving the fine heavy pure stock to be graded on the sieve.

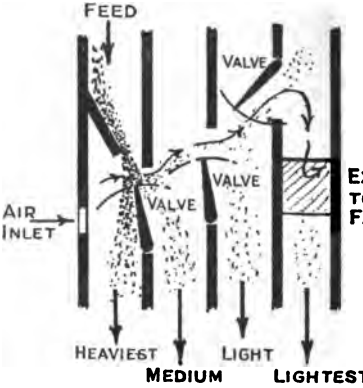

FIG. 89.—PRINCIPLES OF AIR SEPARATION ON GRAVITY PURIFIER.

Fig. 89 expresses the main principles of the old gravity purifier or sorter (pneumatic). The system of air expansion and contraction applies here, and an adjustable weighing of the various endosperm particles is obtained by the altered angles of the valves upon which the parts of feed impinge.

Weighing or separating by air alone was found to be effective only upon semolina and large middlings from hard wheats which naturally gave sharp free stock. In England, therefore, the air-belt purifier has not found favour. Middlings

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and semolina have to overcome the upward drag of the air currents by their specific gravity before they can be termed fully "classed," because their value lies almost solely in ***weight.*** This implies purity also, in most cases, because the ***heaviest*** consists of glutenous (strong) particles, the ***medium*** consists of starchy (medium strength) particles, and the ***lightest*** consists of weak particles and offal. To exactly separate these grades of stock is the purifier's duty. To illustrate the first principles of purification, we will take two purifiers coupled together and dealing with a primary grade of stock between them. The feed consists of coarse semolina with a percentage of branny particles present. It is therefore necessary to have two divisions of the coarser branny particles rejected from the "throughs," in order to further separate

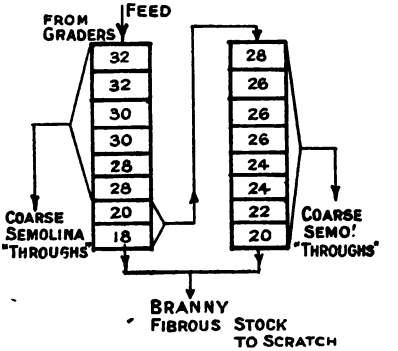

FIG. 90.—COVERS FOR PURIFIERS —COARSE SEMOLINA.

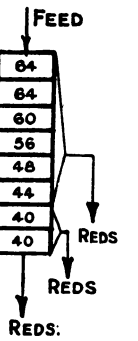

FIG. 91.—FINE SEMOLINA PURIFIER COVERS.

good stock on the second machine. Fig. 90 shows two sieve purifiers fully fed, having cover numbers suitable for tailing over a good percentage of the bran particles present, obtaining pure "throughs" from the greater part (four-fifths) of first purifier sieve, and leaving the last one-fifth of cover with a thinner feed of coarser stock, including branny and fluffy material. On this last section, therefore, the air has a greater lifting power and removes the bulk of light fibrous stock. This 20–18 mesh section being a coarse cover passes all but the branny stock, sending it to the second purifier for special separate treatment. The second machine, being fairly free from fluffy and fibrous stock, can now subject the

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feed to a strong aspiration, and obtain well-defined separations. If the first purifier was clothed finer, say 34–30, all the tailings (no cut-off being possible) would have to pass to the second purifier, thus including all the branny and fibrous stock and greatly hindering its usefulness. If clothed coarser, say 28–18, the overtails could be passed away, but no pure throughs would be possible, and all would have to be again treated on the second machine.

For treating fine semolina, Fig. 91 gives useful cover numbers; while coarse middlings, being somewhat akin to coarse semolina with respect to branny fibre, the flow, Fig. 92, giving two purifiers coupled, will show best and most economical

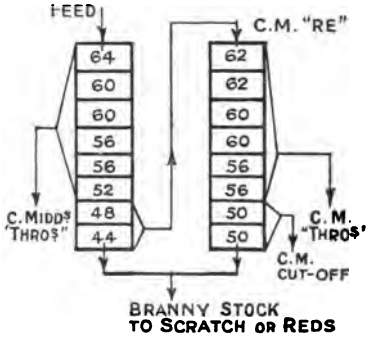

FIG. 92.—COVERS FOR PURIFIERS —COARSE MIDDS.

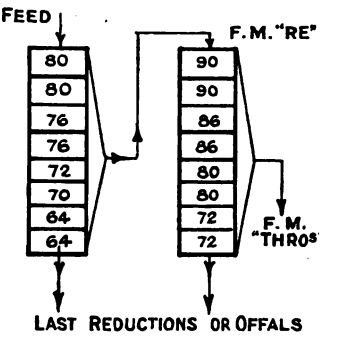

FIG. 93.—COVERS FOR PURIFIERS —FINE MIDDS.

results. For treating fine middlings and dunst the purifiers must be carefully clothed, or much good stock will be lost or contaminated. A sound system of covering will be as Fig. 93.

Although the " tins " or " trays " (the stock lifted by the air currents and deposited in the special catch-troughs above the sieve cover) are extremely fine and light, it is sometimes found profitable to purify these in large mills where the aggregate is considerable. These examples must be taken as the main lines upon which purification proceeds, rather than as the final working sizes. So much depends upon the general scheme of grading. As a rule it is correct to clothe purifier sieves with a mesh slightly larger than that of the duster and grader, over which the stock has just passed. The coarsest number through which the feed has passed gives one

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extreme, and the finest number over which the feed has passed the other extreme. The stock on a purifier sieve is rendered more buoyant by the upward lift of the air currents. This tends to ride stock over meshes through which it would otherwise dress. As long as the air suction is maintained, there is no danger of impurities dressing through the cover with pure heavy stock of the same size, because the former, being much lighter, will be lifted away and above cover into the special receptacles provided. In practice the chief trouble is experienced in purifying the largest particles (coarse semolina) and smallest (dunst). These two grades of material are neither so pure nor so free and sharp as the medium sizes of stock, which range from medium semolina to fine middlings, say from 48–76 meshes. Too coarse to hold much flour and too fine to hold branny middlings to any appreciable extent, these are the purest grades, and from these we obtain our best flours. To deal with the coarsest material we have to use purifiers coupled as already referred to, and send the residue of the coarsest stock to the "scratch" system. In large plants this latter has created quite a little milling system to itself. The other difficult stock is the smallest—dunst and "stive"—running from 76 to flour numbers. At this stage all material most nearly approaches the same size, weight, and general characteristic. Separations by gravity, size, or shape are almost impossible. The greatest care must be exercised in choosing covers, regulating air-draughts and in treatment as to "flowing." The principal trouble will be to remove "greys" or fine pieces of offal thickly mixed with fine granules. Primary and repurifying are the most effective with this stock. The term "primary purification" means the treatment of stock direct from the scalping and grading system. **Secondary, or "Repurification"** means the treatment of stock which has already been run through a purifier, and sometimes through a reduction roll, but which needs additional work upon it, not because of faulty work, but because the stock is composed of impurities which have either adhered to or are the same size and specific gravity as pure middlings. These particles, passing through the purifier covers, will go with the pure middlings to the first reduction rolls, and will either be "cut-off" on the tail-sheet of dresser, or will tail over. This being too large and too impure for flour will be sent back to be repurified before it is ready for final treatment on the reduction rolls. Where the plant is small, it is advisable

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to purify the finest stock from the last break, as this will contain some valuable dunst. The stock comprises dunst and fine bran particles, which, if left in and dispatched to the reduction rolls direct, will yield flour of a brown tinge. The purifier, however, will remove this bran fibre, and a much superior flour will result.

Types of Purifiers.—The purifier most widely used in England is the sieve purifier. Most makes are narrow, having sieves of from 10 inches to 18–24 inches wide, and 6 feet to 8 feet long. Sieves are made of uniform width throughout, a typical example is the Koh-i-noor made by Messrs. Robinson. Although

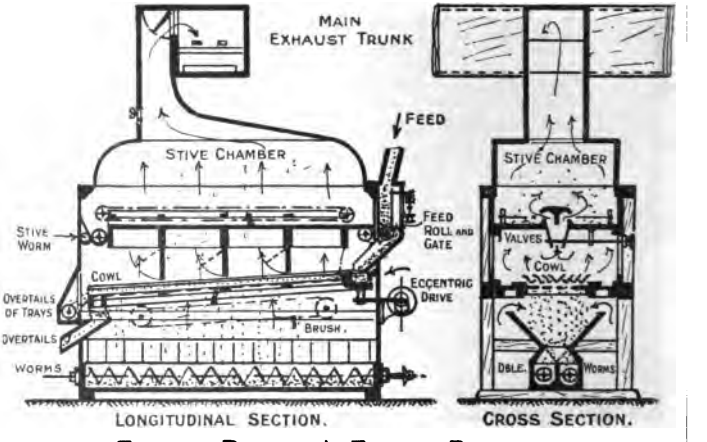

FIG. 94.—ROBINSON'S FANLESS PURIFIER.

the feed on sieve is gradually thinned as it reaches tail end, the four divisions of expansion chamber above enable the air current to be adjusted to suit the altering thickness of material and give uniform results. They can be obtained either single or double in one frame. The sieves are eccentric-driven and usually run at 500 revolutions with small drive pulleys 6″ × 3″. Figs. 94, 95, 96 give useful sectional views of well-known types, and these deserve careful study.

In Fig. 97 the fan is fitted above the expansion chamber. The available sieve area is the standard by which the capacity for work is judged. It is usual to employ from 900 to 1000 inches per sack. The sieves vary from 720 square inches area to

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2300 square inches area. It is advisable to use the first in small plants, in order to have sieves well covered, with the small feeds available. The air-belt purifier is unsuitable in England, although the Americans find a wide use for it. A machine which is a cross between English and American designs is given in Fig. 96. It has a reciprocating sieve like the former, and a system of air-circuiting like the latter. A typical machine of this class, and from which the illustration is taken, is the Samuelson air-belt purifier. The frame contains a reciprocating sieve entirely boxed in, and the stock travels down this and dresses through in the ordinary way. It is also provided with cross-trays and revolving brushes. Placed above the sieve and combined with the purifiers are three chambers, which constitute a complete filter dust-collector. The bottom chamber is hoppered, through which the air-currents are drawn, operating through the

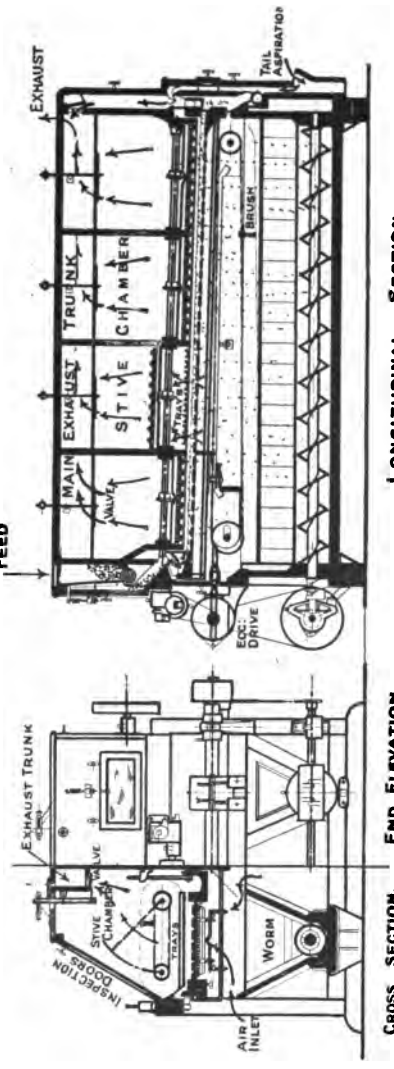

FIG. 95.—SIMON'S FANLESS PURIFIER.

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purifier cover. The middle chamber is fitted with textile filtering tubes, which communicate to both bottom deposit chamber and top expansion chamber. All the air drawn into the fan must first come through the filter tubes. Thus it is claimed that the air reaches it in a clean state and is discharged down the trunk to the chamber beneath the sieve, ready to start operations once again. Each tube is cleaned automatically and periodically, and the stive, falling to the bottom of the collecting chamber, is brushed into the worm at the end.

Several other types of purifiers are now on the market, such as the cyclo-pneumatic dunst purifier, the semolina blast purifier, etc., but these cannot here be described for want of

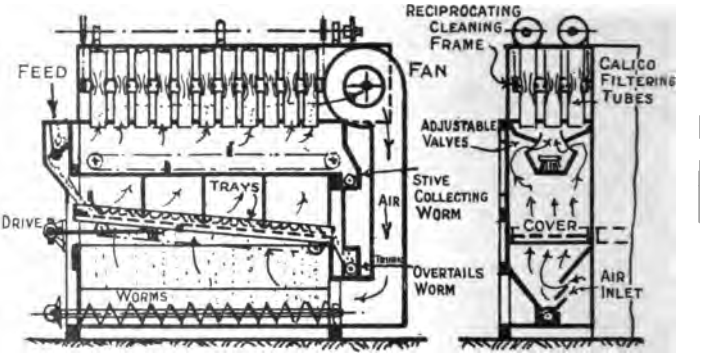

FIG. 96.—BANBURY AIR-BELT PURIFIER.

space. All types of sieve purifiers are much the same in principle however much they may vary in details, whether the tins, trays, or cowls above the sieve are whole, segmental, horizontal, or inclined, and whether the air valves above these trays are hinged flaps or sliding boards—the idea involved is that of the law governing expansion and contraction of air; that its velocity is in the inverse ratio of the opening, that is, the smaller the inlet, the greater will be the travel of current. The lifting and sustaining capacity of air currents is in the same ratio as the speed, hence to carry away stock, the draught must be sharpened; and to deposit, it must be "slowed down" or expanded. To apply this to the action of sieve purifiers. The stock travels, in the approved even stream, down the length of the long, narrow sieve. This is so arranged

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and boxed in, that the fan can only obtain the air supply from beneath and through the cover. Thus the whole of the feed stream is subjected to an uprising suction, sufficiently powerful to lift away the lightest particles present. The heaviest, fine, and medium particles will fall away through the sieve meshes of the respective sections of cover, and will be deposited in the worm conveyors below. Stock, which is too heavy to be lifted and too large to dress through, will be tailed over at the end of sieve and receive further treatment elsewhere. If the exhaust was now drawn direct to the fan, it would carry all lifted stock with it and discharge it to waste (in the "dust" collectors). Before the fan is reached, however, it is, by means of valves and expansion chambers, expanded, contracted, and expanded several times. At each change it is forced to drop some of its burden, commencing with the heaviest particles, and finishing with the finest stive, until it is finally drawn into the eye of the fan and discharges practically free from dust or stive. The limit of this duplication of expansion chambers is only reached when the fan exhaust is in this state. In operation the feed enters the box at the head of machine and is spread, by an automatic feed-roll and gate, evenly across width of sieve. The incline and the reciprocation of this sieve starts the stream of stock steadily travelling down the length of it. At the same time the fan above is drawing air through it and lifting away fine floury stive and offal and lightest branny particles, depositing them in the trays directly over sieve, the side deposit channels, or the top expansion chambers. Pure stock dresses through the cover, and coarse impure stock tails over, receiving a special

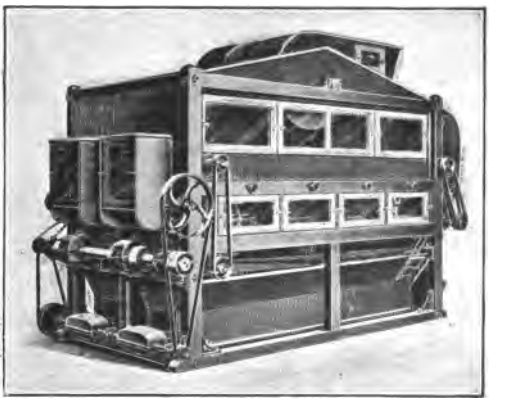

FIG. 97.—TURNER'S DUSTLESS PURIFIER.

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aspiration in so doing. The sieve cover is divided into four sections, each succeeding one being clothed coarser. The chambers immediately over sieve and trays are also divided into four compartments by close-fitting hinged boards so that the aspiration can be separately controlled to exactly suit the stock passing. The sieve is made either of a number of small detachable sections, or in one piece, with silk-tightening gear. A travelling revolving brush keeps the cover free, by brushing from beneath. Travelling brushes are employed to sweep out the trays, and travelling scrapers collect the stive deposit in top chambers, delivering it to a worm conveyor as shown. Main points in purifier construction and working: (1) absolute rigidity in framing and fixing; (2) Perfect balance of all driving parts (especially of eccentric drive to sieve) so that no false action is set up in the movement of sifting surface; (3) single eccentric drive, superior to the double eccentric drive; (4) adjustable sieve hangers, so that sieve surfaces can be kept perfectly level across width and at the correct incline in length to ensure even feed covering; (5) sieve coverings perfectly taut and free from twist. As already mentioned this is accomplished in two ways—in sections, or whole throughout; (6) sieve meshes must be kept free from clogging by brushing automatically. The "roller" revolving type is a very useful one; (7) All sieve and frame joints must be kept air-tight, the junction between the sieve and frame being usually covered by wash-leather. Clear space must be left below for air inlet to fan; (8) the catch-trough or tray system must be fitted. They have greatly helped to make purifiers so efficient and so widely popular. There are several approved types of deposit trays in use. Many years ago the "Victoria" purifier by Messrs. Higginbottom and Co., employed tin nozzles, through which the air was drawn, and light impurities lifted in this way, were deposited upon inclined boards which emptied into conveyor. The simple open form of tray is now widely adopted. It consists of a blocked tin or sheet-iron tinned trough. Figs. 98

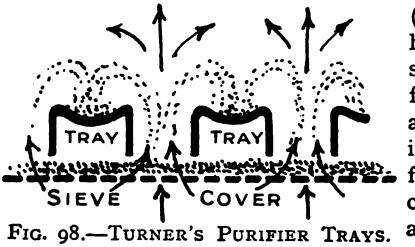

FIG. 98.—TURNER'S PURIFIER TRAYS.

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and 99 give some well-tried designs. They are usually arranged in sets upon wood bearers, just filling space enclosed by the division boards above sieve, and are easily lifted and slung well above cover, when it needs inspection. In the Turner purifier they are run across sieve, and in the Robinson Koh-i-noor, placed longitudinally. Messrs. Simon have simplified their aspiration on the " Reform " purifiers. The tins or channels are made in sections, so that the silk can be inspected at any point. They are placed parallel to, and close down upon the sieve, but are set at an angle of 45° with the centre line of machine. They deliver the stock into side shelves. A single stive chamber is fitted with steeply inclined tin channels which also discharge stive to side shelves below. The figures just referred to show the action of air currents

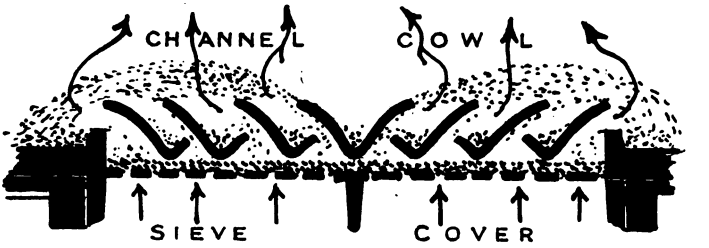

FIG. 99.—ROBINSON PURIFIER COWL.

whilst depositing stock into the trays. It will be seen that the air, after searching through the layers of feed, and seizing upon the lightest particles, passes up between the trays, and is contracted and sharpened, thereby obtaining increased lifting capacity. Immediately the open space is reached, above the trays, the air expands rapidly and drops the greater portion of its burden, which, being driven out of the path of currents, automatically settles into the quiet spots above the trays and side-channels. A special arrangement of deflectors and valves is made to treat efficiently the overtails of the purifier sieve, there being here a last chance of further lifting away impure, light beeswing and stive; (9) the fan must be large, slow-running and of ample capacity, speed about 150–200. The full, steady current of air, thus created, being more reliable and more perfectly governed than that supplied by a small rapid fan. It must draw its air supply only through the sieve cover and tail delivery, and must have free outlet

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for its exhaust. As a precaution against an excessively dusty feed or humid air exhaust, bell-mouthed cowls are usually suspended above the fan exhaust, but quite clear of it. These open into a large main exhaust trunk operating the whole range of purifiers. The suction is supplied by a fan, exhausting to a collector. Quite recently these latter have been of the enclosed tubular type placed in the mill and having the air vent connected to the open air. The latest development in the wind supply for each purifier is that in which the whole range of machines have their suction from one main exhaust trunk and powerful exhaust fan; (10) valves controlling air-currents to be readily adjusted for any section of cover; (11) hopper beneath sieve to be fitted with narrow turn-over valves the whole length, so that the "throughs" can be diverted to either worm at any point when so desired; (12) constant speed of driving shaft to be maintained; (13) all bearings to be self-oiling and dust proof. Eccentrics and eccentric bearings adjustable to take up wear and prevent knocking; (14) feed mechanism reliable, automatic, and spreading stock right across sieve evenly; (15) last expansion, or stive chamber, to be large enough to finally settle all remaining stive; (16) all parts easily accessible, trays easily removable for sieve inspection and renewal; (17) By means of glass shutters, the travel of stock, and the action of stive-lifting air currents must be open to inspection; (18) test-samples of all stocks readily obtainable. Feed sometimes tends to ride over with the tailings; the remedy is to adjust the "hang" and angle of sieve and apply more efficient suction. Uneven running or badly stretched silks will cause feed to ridge up in places and kill the aspiration, besides spoiling dressing and grading action.

"Reform" Patent Purifier (Simon's).—This machine is an interesting one, being of the fanless type. Fig. 95 almost explains itself. One main exhaust trunk running down the length of the purifier floor can be made to operate several of these machines. Above the sieve the expansion of air takes place in the one large stive chamber, the large number of trays receiving the bulk of the stive lifted from the sieve. The large glass inspection doors, forming the sides of the machine, enable a direct inspection of the tray deposits.

Purifierman's Duties.—Keep machines running truly and all bearings cool. Regularly take samples of all stocks so as to detect any variation or faulty work on the part of breaks,

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scalpers, or graders. To report any such difference to roller-man. To keep all parts free from stive and moth. To watch tray deposits and adjust the air-currents to suit. To keep in exact touch with all " cut-offs " and overtails, so that no good stock escapes when a clean-down of sieve might save it. To keep stock stream even in width and thickness. To watch for flaws in covers by examining stock and throughs for impurities and greys.

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CHAPTER XXIII

REDUCTION

We now come to the flour-making section proper, that is, to the reduction rolls and dressers. These receive their feeds from the purifiers mainly. All stock reaching this point should be nearly pure, and free from branny and fibrous material.

Semolina.—The semolina cannot be all reduced into flour in one operation. Roll pressure is proportionate to size of feed particles; the extremely fine adjustment necessary to produce fine flour, cannot be made upon rolls which must pass a good feed of semolina. This stock consists of a conglomeration of minute flour, starch, and gluten cells. The action of smooth rolls is to burst or shatter these, and allow them to shed freely apart. In the one reduction of semolina, whilst a limited amount of single cells or flour particles will be freed, the large part will have been broken into collections of cells, approximately fine middlings. Even if it was possible to reduce direct to flour, it would not be advisable, because of the almost unavoidable presence of branny particles. Therefore, reduce semolina once, dress, take away the great proportion of stock through a tail-sheet, and send a middlings feed to the following rolls and dressers. From these latter will then be obtained the best flours. The residue, the overtails, being composed of branny stock with a good percentage of semolina, will usually be sent to a later reduction roll (sometimes first going to be repurified). Only a thoroughly pure, fine, and even feed can be severely and heavily treated for immediate reduction into flour. From a consideration of these points, the evils of a short system of reduction rolls will be apparent. Because, in such a case, heavy and harmful pressure would have to be exerted upon large stock in the attempt to make flour at one operation and prevent the stock from accumulating and mixing with other much less valuable feeds farther down the mill. Semolina, passed through properly adjusted

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rolls, feels moderately soft and contains no flakes, except those of flattened bran and germ. It will contain plenty of sharp granular middlings and a fair percentage of loose flour.

Middlings.—Practically pure middlings, passing through, say, No. 3 silk, will stand sharp pressure, sufficient to open gluten cells and give the full available strength to flour, and should be finished in one operation. The very small percentage of impurities present will flatten out and tail over the dresser, whilst the granulated middlings, or cut-offs and tail-sheets, will fall apart in atoms, and dress through the silk mesh clothed up to Nos. 12 and 13. At this stage the finest flour is reached. Hereafter, the flour will steadily retrograde in quality.

It is best therefore to gather up at this point all the available good stock, and keep its percentage as high as possible. The principal test of efficient machines and operatives is really the successful work at this point. *Middlings*, coming from the rolls, will feel very fine, free, and granular, being weighty and almost of one consistency throughout, and will be practically all flour.

Dunst is softer and poorer than the finest and smallest middlings. It is as hard to reduce as it is to purify. The fibrous "wooly" particles present in the worst grades, act as a cushion for the rest of the stock and, to a certain extent, prevent the roll from doing its full work upon the pure particles. This stock cannot be rolled many times to advantage. Dunst, rightly ground, yields approximately 70 per cent. of flour at one operation, the tail being sent farther down the mill. Coming from rolls it is lighter than middlings, and tends to cling together in the hand when gripped, being of a soft, light nature. The stock, feeding the last reductions, does not come under any of the three heads just enumerated, but is usually more or less confused, being a mixture of soft and fibrous stock—the unavoidable residue of the whole range of stocks released by the break rolls. A percentage of this stock is so hopelessly muddled that it is quite impossible to further treat it on any kind of sifting surface. This is therefore tailed over and sacked off as offals. Study Figs. 83 and 84 at this point. The following flour list is correct for the majority of systems in England, and gives the places in order of quality and value.

(1) Third reduction dresser, finest white patent strong.
(2) Second reduction dresser, fine whitest medium.

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(3) First reduction dresser.
(4) Fourth reduction dresser (usually from middlings' purifier cut-offs and tailings).
(5) Third break flour.
(6) Fifth reduction dresser.
(7) Fourth break flour.
(8) Sixth reduction dresser.
(9) Seventh reduction dresser.
(10) Second break flour.
(11) All flour from remaining reduction dressers.
(12) First break flour } positions of these two fluctuate with the state of wheat and the mill's working.
(13) Bran flour }

Roll Surfaces.—Unlike the break system, these rolls vary in sectional numbers with the size of the plant usually. A 10-sack plant would do good work upon, say, an 8-reduction system. A 40–50-sack plant would require 10–14 reductions, the feeds being in sufficient quantities to warrant the use of these long divisions. The length of surface, or "inches per sack," ranges from 40 inches to 60 inches per sack. A 40-inch system with 8 reductions would be varied thus :—

A,	B,	C,	D,	E,	F,	G,	H	} total 40 inches.
6	7	9	6	4	3	3	2	

A 60-inch system with twelve reductions would be apportioned as follows :—

A,	B,	C,	D,	E,	F,	G,	H,	J,	K,	L,	M,
7	8	10	7	5	4	4	3	3	4	3	2.

The reason for this unequal division is that the grouping of the fine pure stock always concentrates upon one spot, namely the C reductions. Here, if anywhere, the finest flour can be made in large quantities. Heavy pressures are desirable here, in order to open out the fine gluten cells and release their strength to the full extent. The best work can only be done upon thin broad feeds, hence the large surface required. In the latter reductions the inches of roll surface for any given quantity of stock ground, are not so far below the first as might be inferred by the low numerals given in table. Taking the last four reductions, list gives 3, 4, 3, 2 inches respectively; by this time the greater part of the good stock has been dressed away, and the feeds, although soft and rather bulky, are far less than those for first reductions. Heavy and searching

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pressures and thin feeds are no longer profitable, hence the smaller " inches per sack." The proportions given will not be strictly adhered to in all systems, but will vary with any special feature of the flow. Every scheme controls the amount of feed going to each particular roll, and to that extent governs the " inches per sack " required.

Reduction—Roll Construction.—The remarks applied to the construction of break rolls, apply also to these reduction rolls. The main difference is that the rolls are " smooth." This term must be thoroughly understood if the work aimed at is to be appreciated. When a reduction roll becomes too smooth it presents a greasy appearance and does not grind or crack the stock, but crushes and flakes it. Under the magnifying glass, the surface of a good reduction roll should appear granular ; to the naked eye, of a dull silver-grey or frosted appearance, and slightly rough to the touch. This last condition enables the roll to " grip " the granular stock and crack rather than crush it. The two rolls have a differential speed, and a very smooth surface slips on the particles and flakes them. The safe limit for the length of reduction rolls is 35 inches to 40 inches. The great pressure exerted, renders the adjustment of greater lengths somewhat uncertain, extremely fine grinding being necessary. All these rolls must be fitted with scrapers. Porcelain rolls with a roughened surface were once in favour for flour making. Modern milling practice and the heavy work entailed, has brought the iron roll to the front.

Although most makers at present advocate the use of equal-sized rolls, one make at least, the Robinson roll, are employing differential rolls, 13 and 10, and claim good results from these.

The attention of millers centres largely upon the development of this iron contact surface. The usual method is to use the finely granulated, tooled surface, developed without any special symmetry of layers, but leaving simply the fine natural texture of the chilled iron to be the gripping agency. After some years of reduction work these " smooth " rolls are apt to become too smooth.

The chief argument employed against any designed markings upon these rolls, however slight, has been that the very close pressures employed, preclude any safe use of these without the risk of such markings being stripped. Pressure is not really needed, provided that the essential shattering

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operation is performed. At present the majority of reduction plants perform their duty by a combined crushing shearing action. This, whilst giving good and efficient results upon most stocks, is apt at the highest pressures, to create an appreciable amount of heat and humidity, which must be drawn away by an effective exhaust. The finely-grooved surfaces of reduction rolls, the patent for which (above 80 and up to 120 grooves per inch) is held by Messrs. Frank Stacey and Co. of Birmingham, are of interest, and deserve the consideration of all millers. Therefore the matter is treated in some detail below. The following claims are made by the patentees of the surface:—

"More high grade flour from each dressing machine."

"Brighter, finer, and livelier flour."

"Cooler rolls, cooler dunst, and cooler flour."

"Less pressure in grinding, less coal used."

"Less loss by condensation, little or no exhaust required."

"No sweating of rolls or pasting of silks."

"As this surface gives larger flouring capacity, the feeds on the last reduction rolls are much relieved."

"A number of firms report larger loaves of bread from flour made by this surface."

"Fermentation is even in the bakehouse."

"Detacheurs on A, B, C, and D stock may also probably be dispensed with."

The patentees meet the criticisms *re* wear with the following statements. "Unlike break rolls, the surface is not dealing with tough, leathery bran, but simply bursting up good square semolina and middlings into a fine, lively flour."

"Unlike break rolls, the differential is very slight (4 to 5), consequently the resistance on the teeth of each roll is also very slight."

"As smooth rolls, even after years of work, are not reduced appreciably from the original diameter, the surface is cut into the cream of the roll's chill, which is, of course, the first $\frac{1}{8}$ inch round a roll." As with all new ideas and departures from the beaten track, this innovation is meeting with strong opposition from some quarters, and with absolute indifference from others, but the fact that some of the largest and most progressive millers in the country are adopting it should make most men pause in condemning it. Its work upon the best of the reduction stocks is excellent, when the operative has learned to adjust to suit the altered conditions. The stock leaving

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the rolls is fine, free, and cool. The minute grooves, when examined underneath a magnifying glass, reveal the true saw-tooth pattern, as faithfully produced as in the case of the break roll grooving. The spiral is approximately similar to that of the breaks, but is cut to varying angles as desired by millers. Doubtless in time a fixed standard will be agreed upon, specially adapted to the particular needs.

Reduction Rolls—Rules for Rollermen.—Reduction rolls should receive special mention both as to working and adjustment. As soon as feed enters A it must be followed down systematically to the last reduction, careful examination and minute adjustment of all rolls being an essential, in order to get a clean finish on the last reductions. The automatic feed regulators must be working freely and efficiently, giving an absolutely even and correct thickness of feed right across rolls. The scrapers must be finely adjusted to clean the rolls without scratching or too much friction. Reasonable play must be given to the pressure springs. The feeds should be pure and carefully classified. The ground products must leave the rolls in a silky, slightly gritty condition, free from flaking or softness. They should be cool. Heated stock is a sure sign of uneven or unsteady grinding, uneven or badly worn scrapers.

The following rules are useful.

Stock to feed hoppers to be even in quality, quantity, and size.

Graduated pressure, to suit size and quality of middlings.

As middlings will pass through an opening $\frac{1}{250}$" wide unreduced, the rolls must be exactly true. Make the first reductions, and all rolls on pure stock do full work so that the latter rolls have no excessive feeds.

Heaviest pressure to be applied on tailings to ensure good finish, and on pure fine stock to speedily reduce it to flour in as large a percentage as possible, consistent with cool grinding.

Thin even feeds, no flaking good stock by uneven pressure or uneven scrapers.

Avoid repeated rolling of stock when a working limit has been reached, as this results in loss of strength and life in flour.

Avoid heavy pressure upon scratch rolls.

Keep good and low-class stocks strictly separate.

Shear fibrous stock on latter reductions.

Avoid "Ringing," or rings of pasted stock encircling the rolls, by perfectly adjusted rolls, feeds, scrapers, and exhaust.

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Avoid Flaking by the same means, plus the use of properly granulated rolls, and using no pressures likely to cause heating.

Avoid "Roping," or the gathering of feed into rolls or ropes, by carefully correcting any tendency on the part of feed gear to give uneven and bunching feed streams.

Apply exhaust to carry away generated heat, but not sufficient to lift away floury stock.

Scrupulous cleanliness must be observed both inside and outside rolls. Flaking, already referred to, is especially noticeable upon soft, damp, or germy stock. It consists of flattened or flaked particles of germy middlings, or other reduction stock, which have been squeezed instead of being cracked or crushed. The oil exuding from the germ aggravates this fault and plasters the other stock. This flaking tendency is not altogether an evil when treating stock too full of bran and germ particles, because it ensures that these will tail over the dressing covers, instead of passing through with the flour.

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CHAPTER XXIV

FLOUR DRESSING

In dealing with this section of the milling processes, it is necessary to bear in mind several vital points in our treatment of the stock of the clothing of the covers. In the main, the material is practically "finished," and severe treatment can therefore be meted out to it. If such dressing as a centrifugal gives, is producing flour of a specky and discoloured nature, the fault lies with the grading and purification system feeding the reduction roll, and the remedy must be made there. There is danger, however, in an extremely fine finish to the bran and sharps. To keep these free from a suspicion of flour, is by no means the best class of milling. We begin, in the latter reduction dressers, to take off the residue and tailings as offal. The stock generally has become soft, confused and fibrous, and it is almost impossible to so dress it that no flour goes to overtails and no offals to flour. Of the two evils, the safer is that which whitens the offals, but keeps the low-grade flours a saleable colour and condition. In a long system, the first and second reductions, A and B dressers, might be termed extremely fine graders and dusters, as well as dressers, as they supply feeds, partly at least, directly or indirectly, to the following rolls C and D. If clothed below No. 11 silk, they will produce flour with plenty of glutenous particles, but not sufficiently broken up to give the best baking values. Therefore Nos. 11, 12 and 13 silks are usually employed and dress through all but the strongest flour and stock particles, sending these to C and D for further treatment. These latter rolls send almost pure stock to their dressers. These can be clothed No. 10 silk, and still yield pure, fine-coloured flour. When, however, an extremely fine strong patent flour is demanded from this C dresser, it is usual to place a fine silk (No. 13 to 14) at the head end, leaving the remainder normal. The flour thus produced is sometimes below standard as regards strength. The glutenous particles refuse to shatter as finely as the starchy

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particles. Enormous pressure is used in order to induce this, and in the end the flour shows a higher strength percentage, but at the cost of a good deal of heat and humidity. From E dressers right down to the tail of system, the flour numbers steadily rise as the stock becomes more and more soft, fibrous and confused—until the last two or three reach No. 13–14 and tail over a goodly percentage of offal. Flour milled in England and dressed through No. 10 silk contains more gluten and strength for bread-making purposes than the same stock dressed through 12 or finer silks. For many years the centrifugal has been the principal flour-dressing machine in England. The plansifter is, in some of the latest mills, taking the place of these centrifugals, although upon the last reduction stocks it is still handicapped. The familiar centrifugal presents some curious features in the matter of clothing. The silk numbers of centrifugal in a flow sheet do not go from fine to coarse, but from coarse to fine. A continuous stream of stock must be treated, and the feed carries with it a percentage of fine material which would easily dress through if treated alone. The feed is thickest at the head, and anything like correct sorting at that end is quite impossible if the tail sheets are to be covered sufficiently. The stock is composed of particles of varying size and density. The thicker the feed, the more will the impure particles hold together, allowing the pure free and heavy stock to fall away from it and reach the dressing surface first. As the feed thins, the impure stock starts to get to the silk with the pure; the stock dresses more freely, finer meshes should therefore follow thinner feeds, because the flour must be kept free from offal or "greys." This must be borne in mind when designing flows and cover numbers for centrifugal dressers. The last sheet or half-sheet is often clothed coarser than the previous one, so as to make a further separation of a portion of the tailings containing valuable stock. This is termed the "tail" or "cut-off" sheet. The centrifugal is a slowly-revolving, horizontal cylinder covered with silk mesh, and having a rapidly-revolving set of twisted beater-bars within, to force the flour stock through the cover and to keep large stock moving towards the tail end of machine. These bars, and their c.i. "spiders," or carriers, are fixed to the horizontal shaft, and are carried round with it. The cylinder or drum is made either cylindrical or many-sided (usually 10-sided). It is carried, at each end, by a hollow shaft, surrounding the main beater-shaft, and

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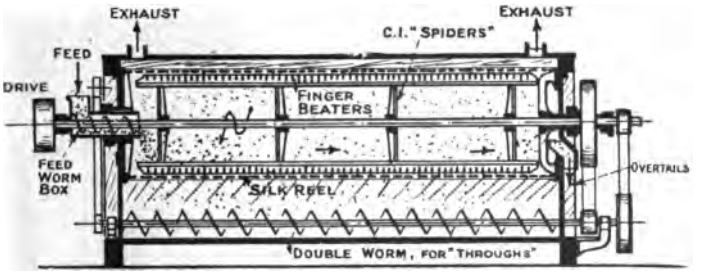
rotates in the same direction, but free of it, and at a much slower rate. The beater-bars are now made in the " finger " pattern (see Fig. 100), and at an incline which can be altered to suit any class of material. The amount of " screw " thus put on the lifters or beaters serves the double purpose of delivering glancing blows for both forcing some of the stock through and propelling the rest along towards delivery end of machine. The feed enters through the hollow circular spout carrying all the cylinder " shaft " or sleeve, and is carried forward by a short internal worm-conveyor. The tailings reaching the end reel casting are lifted to the delivery outlet by guide vanes, and are thus prevented from remaining too long inside the drum. The " throughs " fall to double collecting-worms fitted in hopper beneath the drum. Division boards



LONGITUDINAL SECTION.

FIG. 100.—LONGITUDINAL SECTION OF CENTRIFUGAL DRESSER.

are usually placed at each end of sheet, or section of cover, and, corresponding outlets being made in the room-boxes, enables the miller to keep the various sizes and grades of flour separate. In this way, a small percentage of high-class " patents " can be spouted away from a centrifugal which at another section of the cover is dressing away coarser flour such as Bakers. Cleaning brushes, working automatically, are always necessary. Even then, in bad weather or with soft stock, additional cleaning-down by hand-brush is necessary. All shutters should be covered with canvas to admit air drawn through by the exhaust trunks. The rather steamy warm air within the centrifugal is apt to condense, pasting the cover unless removed. Pitch-pine frames and worm boxes are the best, see Fig. 101. The average size of machine is 24-inch to 30-inch diameter by 2½ sheets long. The reels run at

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approximately 35 revolutions and the beaters at approximately 180 revolutions. As a flour-dresser, the centrifugal shows to advantage. The severe action, in comparison with other types, and the capacity for dealing with overloads, are not undesirable features here, because the stock is either pure or else so soft that gentle action is ineffective. It still remains a general favourite with the miller, because he can depend upon it to meet reasonable fluctuations of feed without waste of valuable stock.

Silkman's Duties.—He must keep the dressers up to speed and maximum capacity by careful attention to lubrication,

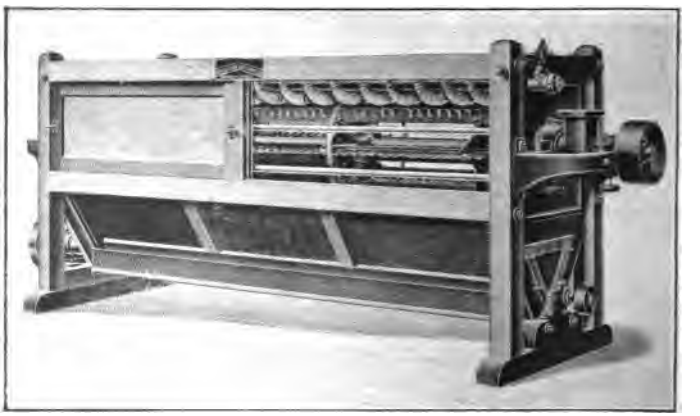

FIG. 101.—BRIDDON AND FOWLER'S CENTRIFUGAL FLOUR DRESSER.

driving belts and gears, special "nursing" being required in spells of damp weather, which render the stock soft and clinging.

Watch elevator head deliveries and all spouts to prevent chokes, those feeding from the fine head sheets of "patents" being very liable to sweat and choke.

Assist finest covers by judicious hand-brushing.

Periodically examine all throughs and overtails to ascertain that no damaged covers are dressing greys into flour-worms, or blind silks tailing over pure finished stock.

Stop all bad feeds by tracing them back to their source at the purifiers, and report these at once to purifiermen.

If working plansifters, keep the running counterbalanced

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as much as possible to avoid vibration. Maintain maximum speed; keep watch over the overtails, especially those going to offal, as these types will overtail too freely if neglected. See that exhaust is fully employed. Keep the sieve-brush well adjusted, and periodically examine covers for choked meshes or threadbare places. Keep covers absolutely taut, but not strained in any way.

Stop, make repairs to either belt or cover, and start up again, with ease and rapidity. In putting on new covers, lace up with great care, so that the surface is taut and even throughout. In this connection it pays even the most expert operative to follow any specialized instructions issued by the machine manufacturers. On cleaning days it is best to take down the patents spouts and thoroughly clean them; also to remove all moth, web and stive from corners of hoppers, worms, or other parts of dressers. He should train himself in the " feel " of all grades of flour, so as to be able to check the pulse of the mill and get the best results.

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CHAPTER XXV

FLOUR

FLOUR is the finely reduced endosperm, and retains many of the qualities and defects of the original wheat-heart. The different cells and layers of the endosperm decrease in strength, gluten percentage, and colour as they approach the centre. Flour, according to its treatment upon the dressers, will vary in all these particulars as the granules become classed. Broadly, flours, although their names are legion, can be placed under the headings of "*Patents*," "*Supers*," "*Bakers*," and "*Households*." Sometimes the whole of the flours made are run together again. This mixture is termed "*Straight-Run*." The highest class of patent is usually taken from the first sheet of C dresser, if below 10 per cent. Patents are made to vary in quantity and quality according to trade requirements. The greater the percentage, the poorer will be the quality, and *vice versâ*. The greatest percentage made is about 70 per cent. A usual quality is 50 per cent. For this, flour would be taken from C, B, A and D dressers respectively. It may require all the flour throughs from these machines. Variations in "Patent" percentages will become wider and the quality poorer the farther the field extends from C dresser.

The lowest grade of Patents, the 70 per cent., would come from A, B, C, D, part E, and III break flour.

"*Supers*" vary from 20 per cent. to 30 per cent. of the whole flour output, usually coming from D, E, F, and III break flour.

"*Bakers*" are drawn from the lower grades of stock, excluding the worst however; must contain a good strength quality, and be free and of fair colour. Bleaching is sometimes resorted to here, to ensure any special whiteness required.

"*Households*" is the lowest grade of all. As long as a fair colour is maintained special strength is not specially demanded. Taken from the lowest grades.

In changing from a 71 per cent. flour yield to a 68 per cent., with first patents of a higher order, the matter rests upon the

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breaking, grading, scalping and purification systems, rather than on the flour-dressing. All breaks must be slightly relieved. The last break, or bran-cleaning roll, must treat the bran much more carefully to avoid stock contamination following upon bare scraping of the bran; all the scalper stock will be somewhat larger, the break flour will be diminished, and the feed to the primary purifiers rather increased. These will tail and cut off a correspondingly larger percentage of scratch stock, but will send superior semolina to the first reductions, which will mean pure free middlings to C roll, and a higher class of patents. The scratch stock, which in a close breaking-down would have lost a percentage of middlings, must now be treated upon the X roll. Strong exhaust must be applied to rolls and purifiers and all dressers. Whilst close finishes must be effected on C and D rolls, the reductions and dressers following will be worked less searchingly, so as to allow doubtful stock to tail away to offal. When aiming at a larger divide of first and second patents, coming mainly from C and D, it is necessary to get the greatest possible feeds of *pure* stock there.

Very finely dressed flour is not good practice, the excessive pressure necessary to reduce the particles to such minuteness tends to partly "perish" the flour, by actually crushing the particles and rupturing the starch cells, instead of cracking them and leaving the reductions granular and lively. In dressing such extremely fine flour through anything above 12–13 silks, in this country, the glutenous flour is found amongst the largest particles and is apt to tail away instead of dressing through with the rest. Whiteness can be obtained by this method, but not the beautiful creamy, lively flour so dependable when the baking test is made. About a quarter of a century ago, flour silk numbers went up to 15–17, with somewhat disastrous results in bread making. The reaction brought the numbers down to 9 for patents. Gradually since then the silks have fluctuated up to the present practice of 11 and 12–13. This is the safe limit for English dressing.

Flour Tests.—The weight of a good sample of flour equals 56 lbs. per cubic foot. The moisture in flour varies from 6 per cent. (dry), 17 per cent. (medium), to 25 per cent. (damp). In testing for strength the quality, not the quantity of the gluten is the real proof. Good strong flour must be heavy, granular and free and damp with a more yellow than blue tinge. If made into a dough and boiled it should be found

swollen tightly when cooked. Dough placed on a flat surface should tend to rise, not spread.

Ready Methods of Flour Testing.—Take a handful of flour (in a north light) and open the hand, leaving the heap to fall apart. A good strong sample should fall apart crisply, show but faint traces of the grip, be a light cream in shadow, granular in particles, and smell of nothing but the true " flour " scent. It must be slightly gritty to the feel, and free from specks. To more thoroughly develop colour and purity, place the heap upon a board, and, using a spatula, smooth the heap carefully out. If tiny black specks are visible, cockle will be present. If dull brown specks, called " greys," are present, bran and offal will have leaked in.

"Pekar's" Test for Colour.—Place small heaps of the various flours on a long narrow black board, flatten carefully to equal thicknesses with a spatula, and dip the whole board and contents carefully into water, allowing air-bubbles to rise before removing. Good flour will appear creamy-white and die off to a yellow-grey. Poor flour will appear dirty cream and die off to a dark or whitish-grey.

Bakers' Tests.—The final test is that of baking. The dough is judged by its shortness and rising capacity. It must not stick or cling to the fingers in working up. The strength of flour makes a difference to time in working. Weak flour works faster than strong. The moisture takes longer to penetrate the latter. Strong granular flour is likely to work into a more consistent dough than fine weak sorts, giving a fine-bloomed high-piled leaf, rather porous, nutty and wholesome to taste, masticate and digest.

One instrument used for flour-testing is the aleurometer. It is not altogether satisfactory, as it gives only the *quantity* not the *quality* of the gluten. Poor gluten will expand rapidly and readily, but will not be elastic, ductile or tenacious. In the aleurometer a plug of gluten, obtained from the flour under consideration, is inserted into a tube fitted into a case heated by immersion in hot oil. The gluten, expanding as it becomes heated, rises in the tube and is registered on a graduated scale. Three common strength tests are (1) Doughballs; (2) doughballs boiled; (3) baking.

(1) Doughballs, made by kneeding 4 ozs. of flour with 2 ozs. of water until the whole mass is of a consistent nature, are placed upon a clean dry board. If the dough, on being handled after a time, slackens into long strings and handles

sticky or tends to spread upon the board, and to stick to it, if left for half an hour, it is probably weak. If it retains its shape but dries quickly and cracks like putty, and has practically no elasticity, it is almost entirely *deficient* in gluten. If flour doughs up clean, makes a tough dry ball of short elasticity, retains its shape if left, and tends to rise, does not stick, but can be spread out into a thin film, it is strong.

(2) The boiling test consists of making doughballs as before, tying them tightly in coarse calico cloth and boiling them for thirty minutes. If, on being removed, these "puddings" are swollen plump and stiff, and retain the imprints of the cloth, the flour is strong. If they are soft, slack and sticky, the flour is weak or damaged, and may be from frosted or sprouted grain. Russian, Canadian, or English have these faults at times, the first two being weakened by frost and the latter by sprouting in very wet seasons.

(3) The baking test is the most reliable. A sack of flour—280 lbs.—mixed with approximately 1½ lbs. of yeast, 60–70 quarts of water (150 to 175 lbs.) and 3 lbs. of salt. The heat in baking causes the mass to rise, by inflating the innumerable minute cells encased with gluten. If these are not sufficiently strong, the expansion of the gases will burst them, and cause flat, puny loaves. If the cells hold for 50–70 minutes at 500° F. (baking heat) then the gluten is of good quality, and the flour strong. A high-piled loaf should result.

The essentials in a good strong loaf are: (1) *Golour.* Whiteness of crumb with bloom, same ages of loaves being compared. (2) *Volume*, general bulk, length and height with perfect shape, uneven bulking being a sure sign of uneven qualities of the gluten. (3) *Porosity.* The texture of loaf should be uniform throughout the mass and relieve the closeness. (4) *Texture.* It should be firm and not too solid. Crumbiness indicates deteriorated gluten or excess of gliadin. (5) *Elasticity.* It should retain or regain its shape under pressure and be relatively light. (6) *Crust.* This must be of a healthy reddish-brown tint, or clear yellowish-red. It must not be of an opaque or leathery texture nor flake off. (7) *Flavour.* Should be sweet to smell and taste. Strongest aroma given off when loaf is just warm from the oven. Should masticate crisply. This latter quality is a good indication of successful wheat blending.

Amongst the many tests for "quality-strength" in flour, it is interesting to take note of those by Mr. A. E. Humphries,

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the well-known milling expert. He states that ***gluten which resists the bursting tendency due to expansion of gases in baking***, is one test of strength, also capacity to make large, shapely loaves; behaviour of dough as a quality-standard, called stability, and a well aerated digestible loaf.

Whiteness in Flour—Natural and Artificial Bleaching.—There are three ways of bleaching: (1) by treatment in cleaning, conditioning, and milling; (2) by storage (or natural bleaching); (3) by artificial bleaching, using electrical or chemical agents. Wheats will yield their flour in the whitest, *i.e.* uncontaminated, state best by careful cleaning and conditioning. A wheat often used and usually cheap and plentiful is White Kurrachee. Some grades have a slightly yellow cast, very difficult to entirely eliminate. The best practical treatment is to very thoroughly dry-clean, with strong aspirations repeatedly; then steam or double wash, condition or dry smartly, but not too searchingly, stand in bins for at least twenty-four hours (exposure to daylight for this period is also beneficial, and some millers recommend storage in a damp state in bags). After strong aspiration and brushing, weigh on to the first break. Here great care must be exercised in adjusting pressures, so as to make as little break flour and bran powder as possible. Purify rather coarsely, because the stock has been kept large in order to avoid break flour and small stock. On all but the first reduction rolls, roll finely and smartly, so as to release flour at the first opportunity, dress through fine silks 12–13–14. Whatever fine middlings and dunst are made must be purified to a high degree. On the latter reductions, the stock must be dressed finely, even at the expense of white and floury offals. The lowest grades of flour must be kept to themselves. An extreme case is taken for the purposes of illustration.

The second method of whitening flour is by maturing or ageing it by storage. The agents present in all pure fresh air attack the flour in the sack, extracting the colour-rays slowly and giving it improved general baking qualities. The best results are obtained in flour from which the germ and offal particles have been carefully excluded. Professor H. Snyder, of Minnesota, investigated flour in storage. Samples were stored for four, eight, and twelve months respectively in dry, well-ventilated warehouses, and then compared with freshly milled flour. The loss in moisture was 1 to 2 per cent. No signs of fermentation could be detected. The flour was much whiter than the new stock. The resultant loaf proved superior.

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Flour must be stored in sacks at about 50°–60° F. on a dry, boarded floor in a good atmosphere. Gain in value will be 6*d.* to 1*s.* per sack, judged upon the colour and working of the bread. The third system is artificial bleaching. It aims at doing in minutes what Nature does in months. Long storage is rarely possible in modern mills, short cuts are naturally sought. The aims of the various processes now in use are directed mainly to rendering the flour extremely white by the extraction of the colour rays from the particles, thus making refraction more delicate. This, and the ageing of the flour, are all that is really sought for. The fatty matter present in the flour imparts the delicate cream tints to the whole mass. These are most affected by the bleaching. Bleaching, properly carried out, "fixes" the acidity of flour and prevents it from turning sour under trying conditions. A certain amount of sterilization takes place. The best features of this treatment are seen upon flour designed for the tropics, where it resists the bad effects of great temperature and humidity. Bleaching drives off a certain small amount of moisture and takes some part in determining the flavour of the resulting bread. Over-bleaching will produce a flour giving a decided grey cast to the crumb of a loaf. Tests have been made in which the flour used had a yellow tint, such as obtained at times from Kurrachee and some American Winter wheats, and in most cases a decided gain in whiteness has resulted. Removal of all germ particles is an essential for effective work. Varieties quite good in strength and yield, have a yellow tint, more or less pronounced. On account of the price and abundance of these kinds at some seasons they must be bought. Here is the place for the bleaching apparatus. It will remove any pronounced defect in colour without robbing the flour blend of its bloom and good qualities. It is the excessive use of bleaching which has laid it open to adverse criticism. High-grade flour, not necessarily the finest, contain most of these oils in a pure form, responding more thoroughly to the bleaching than those in low-grade flours. These latter usually contain a fine percentage of very minute "greys," or bran shreddings, upon which the bleaching agents waste their forces. Absorbing these products they rob the flour particles of their legitimate bleaching.

It has long been known that pure ozone, and a few other "gases," whether produced electrically or chemically, would change coloured matter in flour from lemon yellow to a clear

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transparency without colour rays, but that they, sulphur fumes especially, left some taints behind, and were therefore impracticable. Many processes in use have succeeded in removing these objections. Flour, whether bleached by long storage or by artificial means, increases in acidity with temperature. But, whereas the naturally bleached flour seems to increase in this particular indefinitely, the artificially bleached better-class flour especially, does not alter beyond a certain point. The lower this increase can be kept the better, of course, will be the flour for baking purposes.

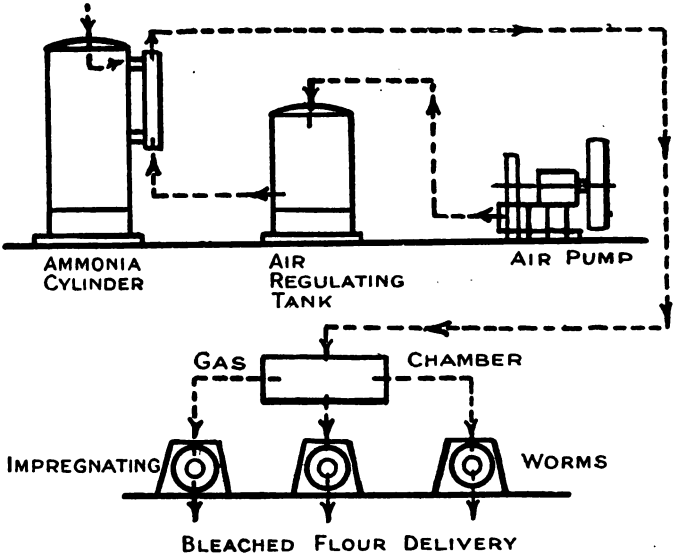

FIG. 102.—EXOTHERMIC FLOUR-BLEACHING PROCESS.

To deal with representative systems of flour bleaching—

The *Exothermic Process*, by Messrs. Henry Simon, Ltd., consists of (1) an air compressor, (2) an air tank, and (3) an exothermic apparatus attached to an ammonia cylinder. The idea carried out, is the blowing of impregnated air or gas through the flour. The gas consists of a large percentage of air and a small percentage of ammonia. The mixture is made by passage through a heated platinum tube before treating the flour. Fig. 102 explains the flow. It is claimed that bread made from the treated flour keeps fresh longer than

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that from the unbleached article. That it bulks slightly greater in the baking, and that the crumb is distinctly whiter. The amount of treatment, or bleach, can be regulated as required.

The *Alsop Process*, for which see Fig. 103, works on the lines that air drawn through an electrifying chamber, and then blown through flour, will mature and whiten it. This system

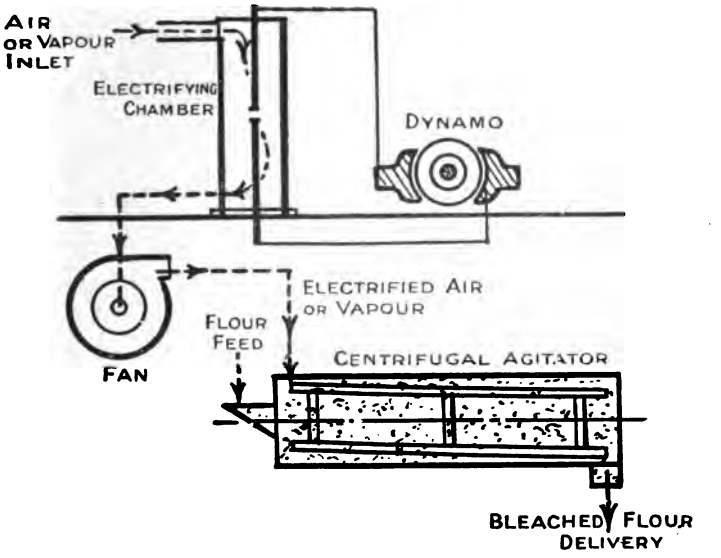

FIG. 103.—ALSOP FLOUR-BLEACHING PROCESS.

is really intensifying all the actions of natural bleaching. It consists of (1) an electrifying chamber and dynamo, (2) a fan, (3) a mixer or mixers containing revolving beaters. The air is usually drawn direct from some pure clean source, although in some plants of this process it is drawn through a vibrating vaporizer, giving off offal fumes. The enriched air is stated to be beneficial to the flour under treatment.

Recently *improvers* and *enrichment processes*, acting upon the stock during manufacture, have been introduced. One, employed in numbers of mills commercially, is the Humphries Process. It is divided into two parts, *Conditioning* and *Enrichment*. The conditioning process consists of subjecting mill

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stocks, such as semolina, middlings and dunst, and flours, to a finely atomised water spray. In the enrichment process yeast foods, such as diastase, maltose and dextrine or solutions of phosphoric acid or acid ammonium phosphates, can be used. These are dissolved in water in desired proportions and sprayed into the stock or flour by the same apparatus as used for the conditioning process. The advocates for this system of treatment state that it enables the safe use of wheats deficient in natural phosphates or other soluble salts, through bad harvest and climatic conditions, by supplying that deficiency at the best time, *i.e.* when the endosperm particles have been thoroughly divided, thus improving the baking qualities and taste of the resultant flour.

The systems, such as Humphries, Lorings or Levins, all aim at restoring the moisture to stocks lost during milling, (*conditioning*) and enriching the flour by the addition of weak solutions of phosphates—(*enrichment*).

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CHAPTER XXVI

OFFALS—GRADING AND PACKING OF ALL STOCKS

When the stocks, rejected by the milling systems as being no longer fit for treatment for flour extraction, are tailed away they must be dispatched, especially in large mills, to the offal-grading systems for classification. All stock of a branny nature should be sifted and rolled to obtain the maximum of bran. Where the cleanest screenings from the wheat-cleaning are ground up as offals they must also be fed into this plant for grading and blending with the fine bran, coarse and fine sharps. The main points in a milling system where these products are rejected as " finished " are trays of latter purifiers, overtails of secondary purifiers, overtails of bran-duster, overtails of dresser receiving flattened germ, overtails of last two or three reduction dressers, exhaust stive from rolls, centrifugal or other dressers, purifiers, scalpers, and graders, deposits in all dust collectors. From the cleaning department will come usually clean screenings, either whole or ground according to their natures. The dried bran-mash, recovered from the (cleaning) washing plant, will also be available for mixing in with the coarse sharps and bran. All stocks, except the broad and medium brans, can be run together into large reels and a final separation given to the fine sharps on a centrifugal. The separations and divisions, as made, will be run straight to the packers from the delivery worms and hoppers of each machine, see grading flow, Fig. 104. As there is no danger of contamination at this stage, where all the stocks are " impure " in the milling sense, the repeated dressing and grading will be found beneficial for such soft and clinging stock as tailed over by the latter reduction dressers and the stives.

Offals are packed usually in a corner of the warehouse, being sacked off from wood spouts or sleeves beneath which the bags are hung. The packers in charge are kept fully occupied in a large plant. The brans especially are often light and flaky and give a good deal of trouble in " possing "

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or compressing, by possing stick, into the required size of bag. Brans are bagged up into 8 stones (1 cwt.). Offals (coarse and fine sharps) into 8, 10 and 12 stones. These latter are usually topped two-high, whilst the brans are laid on side. Bran-bags, being large and bulky and somewhat unwieldy, do not stack well on end, and for that reason are laid on the floor and " bonded " in.

Packers should see that the brans and offals maintain their standards as to size and colour and quantity, and should at

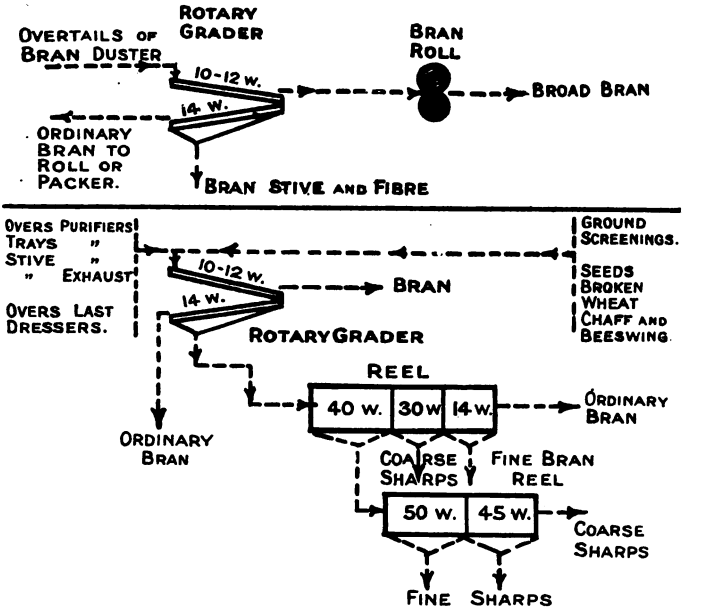

FIG. 104.—OFFAL-GRADING FLOW-SHEET.

once report any serious departure therefrom. The packers of all products, excepting only the brans and coarse sharps, should be automatic " possing." A good natural light is essential for stock inspection. The number of flour packers varies with the grades sacked off, of course, and the divides made from these grades. A 30-sack plant will require eight to ten automatic flour packers (see Fig. 105), for filling either 10 or 20 stone bags. Flour packers should be expert in neatly sewing r tying up the sacks. As the output of mill and flour

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percentage is obtained from their records of amounts sacked off, they should be very accurate in weighing each bag. A glance should be given to each flour as packed to detect any change in it, specially to guard against presence of greys. The modern warehouse, for a large mill, is a separate building from the flour mill proper. Flours are wormed across and offals are banded across the connecting gantry. Bleaching is often carried out on the warehouse floors. All the stocks

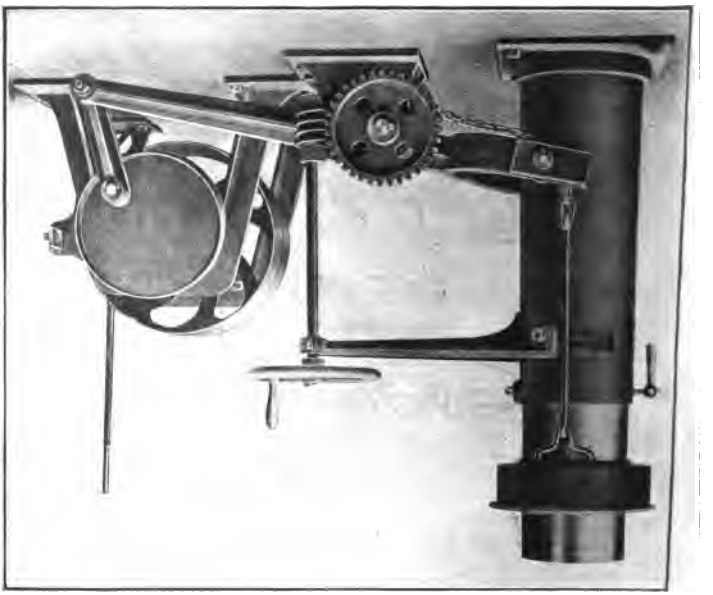

FIG. 105.—BANBURY AUTOMATIC FLOUR PACKER.

stored should be so arranged that a trucking space of at least three feet is left down the centre of rooms. This enables inspection of all stored material and also access to any age of flour or offal. Besides being used as a packing and storing department, it must be fully equipped with all the stock-handling appliances necessary for labour-saving, such as bag-bands, vertical and inclined shoots and sack-hoists. It must also have on the top floor a sack-cleaning and sack-mending room, each isolated from the rest of the floor. The loading-out

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must be accomplished in a neat and rapid manner, to feed, in an up-to-date port mill, railway waggons, road motor-waggons and drays, and in many cases lighters on the dock side. For

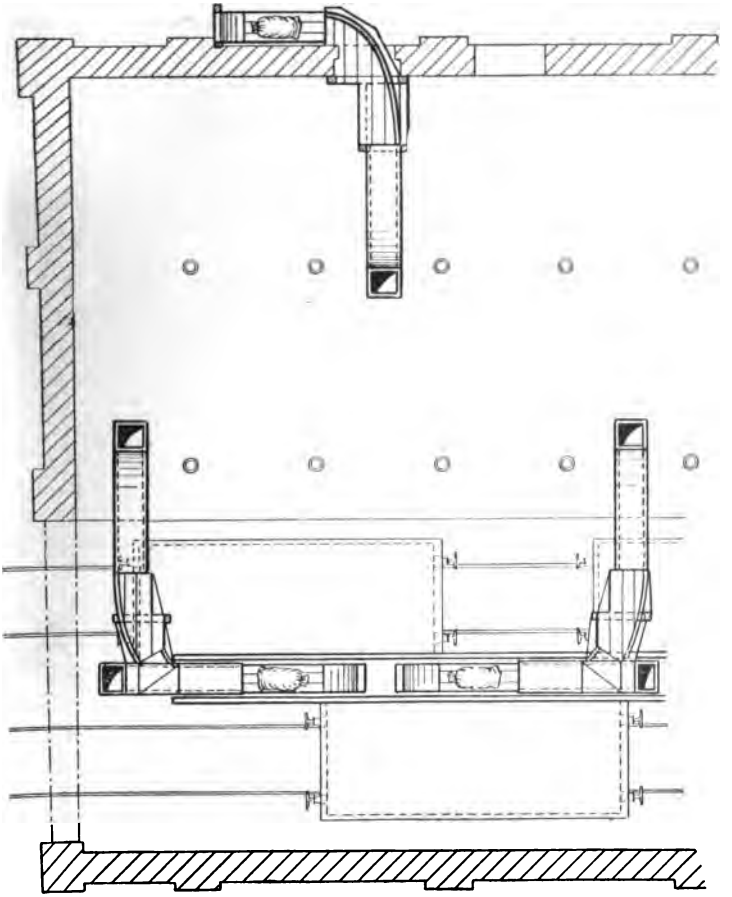

FIG. 106.—PLAN.—SPENCER'S "SWIFT-SURE" SACK SHOOTS.

horizontal conveying the length of the building or buildings, band conveyers, either horizontal or inclined, are employed and found most efficient. For the vertical hoisting of bags and sacks there should be an internal strap and chain hoist

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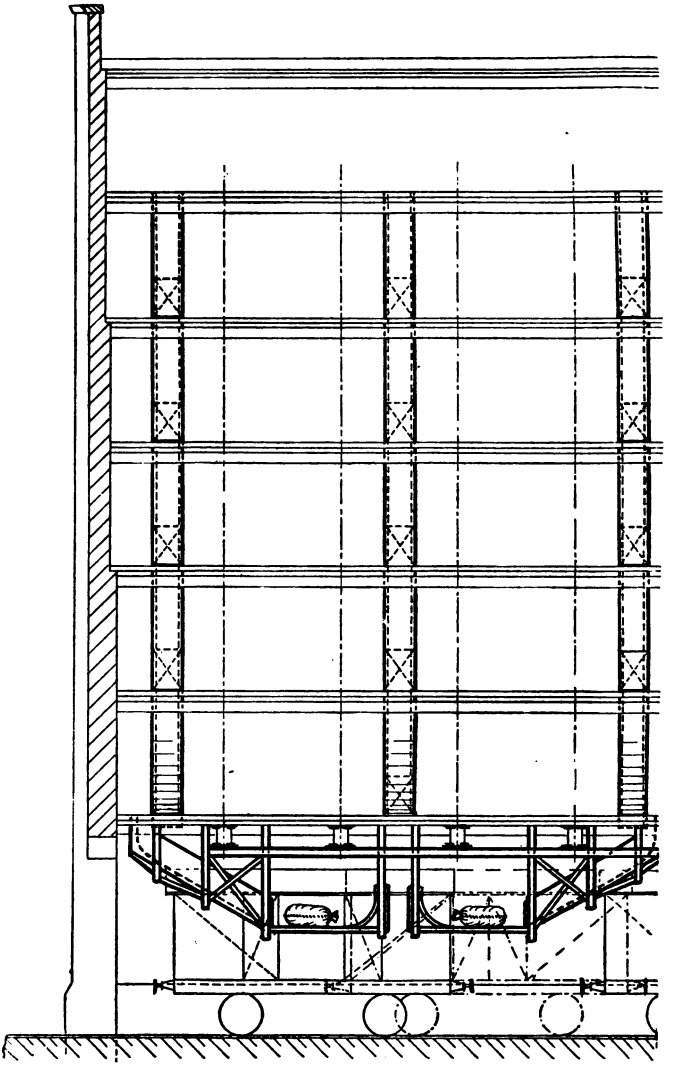

FIG. 107.—ELEVATION.—SPENCER'S "SWIFT-SURE" SACK SHOOTS.

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(Fig. 15), at each end of the warehouse, with trap doors through each floor. The best method of delivery from any floor is by the " gravity " shoots or trunks now in use. A good type is the " Swift-Sure " sack shoot by Messrs. Spencer & Co., of Melksham, see Figs. 106, 107. It consists of a vertical pitch-pine trunk about 24 inches square, running through all the floors and having communication with each by means of movable shutters. On the bottom or delivery floor the trunk is curved away to the horizontal, so as to bring the downward-rushing sack to rest. When horizontal the trunk is open, and shoulder high, so that the sacks can be taken off by labourers and stacked in trucks. Just out of head-room on each floor an electric red light is fixed, so that stock can only be loaded away from any one floor at one time. Directly the door into shoot on any floor is opened, the light is switched on to all the remaining floors as a warning that no tipping must take place there until that one has ceased delivery. The insides of these shoots are highly finished, and the wear and tear upon the sacks is hardly noticeable.

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CHAPTER XXVII

MILL STAFFING AND MANAGEMENT

To the casual visitor a mill seems deserted. The total number of men employed in a big mill is quite considerable, but the relation to the plant is small, the output being enormous. Take, for example, a 30-sack plant. Its weekly output in flour is approximately 1,210,000 lbs. or 4320 280-lb. sacks, and in offal is approximately 363,000 lbs.

The following is a list of operatives employed in all departments :—

Intake (receiving elevator, conveying, preliminary cleaning and dirty wheat storage), day only, 4 men—1 intake, 2 barge-trimming, 1 silo.

Screening or Wheat-cleaning Department (including dry-cleaning, washing, drying and conditioning plants and blending bins), 6 *men*—1 screenman, 1 washer and conditioner man, 1 sweeper and screenings, "sacker-off" (lad), day and night shift.

Flour Mill, 20 *men*—1 foreman for day, 1 assistant foreman (night), 2 rollermen and lad, 1 purifierman and 2 lads, 1 silksman and lad, 1 cleaner, day and night shift.

Warehouse (trucking, stacking, and loading-out), 7 *men*—3 loading, 4 trucking, day only.

Packing, 12 *men*—3 flour packers, 3 offal packers, day and night shift.

Power, 4 *men*—1 engineer, 1 stoker, day and night shift.

All remaining men will be day only, and will comprise : 1 sack cleaner, 1 sack mender and sorter, 1 lad as sweeper.

Cartage, 4 draymen and motor men.

Repairs, 2 *men*—1 millwright (a good joiner and mechanic), 1 labourer.

Bakery, 1 baker and tester.

Stores, 1 storekeeper, general caretaker of all sundries required for all repairs in all departments.

Office or Administrative Staff, 6 *men*—1 manager, 1 head clerk, 4 assistant clerks.

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A properly equipped 30-sack port mill will thus require 70 *men* in all. In managing a mill, the chief must have under his notice and control all the varied details of the mill and its workings, so that for any given week an exact calculation can be made as to the cost of manufacture per sack, the ruling market prices for the period, and the percentage of profit cleared. It is usual for the miller to have a tabulated report of the daily intake of wheat and output of the mill in flours and offals—each 12-hour shift contributing its share, so that any variation between these shifts can be seen at a glance. Also, the output of the cleaning department in cleaned wheat and screenings, whether for offal or to waste. The manner in which these reports are obtained will be as tabulated.

(1) **Intake and Storage.**—(*a*) Number and amount of weighings from ship elevators or other intake apparatus delivering to the receiving department. To obtain this record the warehouseman in charge must chalk down, both on starting and on leaving his duties, the number recorded on the weigher. The amount of wheat passed at each tip guaranteed by the makers, multiplied by the difference of the numbers, will give the total weight of wheat passed on that shift or cargo. (*b*) The amount of wheat passing from the receiving department to the silos will be recorded in a similar manner. The quantity of screenings and rubble bagged up in the preliminary dry-cleaning plant usually installed in this department will serve as a further check upon the difference between these two weighings. (*c*) The amount of dirty wheat delivering to the cleaning department can be checked by passing through weighers or by timing the wheat emptying from each bin through the mixer or measurer set at a required output per hour.

(2) **Wheat Cleaning Plant.**—(*a*) The amount of cleaned and conditioned wheat weighed into the blending bins can be obtained as previous examples. The difference in the amount of wheat entering, and the amount delivering from, this plant will not balance with the screenings sacked off. This latter will be in excess, because some of the lost ground will have been regained by increased weight and bulk due to washing and conditioning. (*b*) The screenings may be divided into three classes. Sound good seeds, such as broken wheat, maize, oats, rye, barley, etc. Inferior seeds, such as cockle, spelt, wild seeds, etc. Rubbish, as sticks, strings, straws, dust, stones, sand, and dirt. The amounts of the first two must be recorded. as they are usually ground for meals or offals.

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The last is not so important, but a check would serve to determine the amount lost in cleaning. (*c*) The records of the water used on washers, and the steam used on dryers and steamers, can only be obtained approximately by recording the time each was used and the pressure employed. As they are an expensive item usually, a check should be kept upon them to prevent undue waste. (*d*) The blended wheat discharged from the clean wheat bins, will have lost weight by storage.

(3) **Flour Mill.**—(*a*) The amount of feed entering the first break must be recorded exactly by a weigher receiving from the cleaned wheat mixers beneath the last-mentioned bins. (*b*) A record of all flours and offals sacked off. It is usual for the rollerman to take an hour's timing at the middle of each shift, entering all details in the " timings " book. (*c*) A record of all sweepings, exhaust-stive, etc., bagged up by the sweeper. (*d*) The amounts of flour set aside for baking, testing, and exhibition purposes are also kept in the larger mills where this is done on an elaborate scale. (*e*) An examination and a report upon all samples of stock in course of manufacture is necessary in order to ascertain that a high standard is reached and maintained. The most accurate checking of I break-feed against the collective weights of flour, offals, and sweepings fails to bring the latter nearer than a 0·5 per cent. loss. This can only be accounted for by evaporation, lodgments, and escape of dust to the open air.

The foreman works out all these particulars and obtains the percentages, inquires into any serious departure from the standards set up in any department, receives the " tally " from the packers and loading-out men of all stocks sacked off and stored in warehouse, and of all amounts delivered to trucks and waggons for transit, and is thus enabled to hand a comprehensive report to the manager, who has then ample data to work upon and to aid him in his decisions as to future plans. The pulse of the power plant is best felt by a record kept of the fuel consumption in the furnaces. These power expenses should be tabulated by keeping an exact record of all its workings in order that a " cost per sack " can be deduced for the power element alone. The following items will be necessary, assuming a steam plant.

Fuel.—(1) Weekly or monthly record of all coal and other fuel consumed, with prices.

(2) Weekly or monthly record of all water used for either

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steam-raising or condensing. All water used from the mains to pass through a reliable meter (water for condensing purposes usually taken from canal, river, and dock, used and returned).

(3) The amount of steam raised per week or month.

(4) Indicator diagram taken regularly from engines to ascertain the power given for steam consumption.

(5) If own generating electric light plant, the amount of current per power unit.

To the full power cost the following must also be added: (6) Boiler repairs; (7) economizer and pump repairs and cleaning; (8) ropes and bearings, also engine repairs; (9) valve and fitting renewals; (10) oil, waste, and sundries; (11) engine attendants', stokers', electricians', and labourers' wages; (12) average interest upon capital outlay; (13) depreciation upon plant and buildings.

From these particulars the miller can ascertain the cost per 1 H.P. supplied to his plant. All these items in a modern mill will work out to about 3*d.* per sack.

It is usual for the manager, foreman, and chief clerk to consult each day, however briefly, upon matters of wheat, stock, and grades of flour most in demand, the day's deliveries and orders received, and also upon any urgent matters referred to in general correspondence. Any repairs needed or complaints received are also dealt with. Changes in wheat mixtures, conditioning, and flour blends are then decided upon, bearing in mind all these governing items. The manager also receives the traveller's reports as to trade in the various districts. He must keep his fingers upon the pulse of the wheat market and the " products " market, so as to anticipate as far as possible any fluctuations in either, avoiding loss and making at times actual gains upon the result of such changes. Charts and data bearing upon the world's harvests and markets, upon the amounts afloat or in port, are also necessary, for constant reference, and here such journals as *The Miller* and *Milling* are of very real help, with their weekly collective information gathered up from all the important markets of the country. He has also to attend the local grain and produce markets upon the special days, buying and selling large quantities of stock. He must be able to judge wheats so as to buy all grades to advantage for the special demands of his trade, as to colours and strength of flours, and grades of offal. The natural wear and tear of the installation as break-down and repairs in power or boiler-house, or any of the departments

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of manufacture or storage. These will consist mainly of renewals to shafting, belting, ropes, and bearings, substitution of pulleys for altered speeds, renewals of silks and other covers, regrooving or regrinding of rolls, woodwork for spouts, trunks, and guards. Sundries such as belt-fasteners, nails and screws, bolts, nuts, and washers, oil, waste, brooms, brushes, and general store details. Sacks are a source of much trouble, being either lost or returned after having been used as a door-mat in some bakery, or damaged in transit.

Periodic stocktaking of all these is necessary. Outside expenses, such as fodder for horses, fuel for motors, repairs to cartage and haulage tackle for both, must be exactly known. Ground, water, gas, and electricity, and sewage rates must be carefully checked. A weekly draft of all stocks, whether raw or manufactured, is advisable, to guide in buying one or selling the other. The manager must also examine periodically the whole of the men's wages and time-sheets so as to get a clear idea of the labour cost. It is usual for the mill to pay workmen employed by contractors on mill repairs or machinery replacements at the rates agreed upon. The time-sheets for these men must be checked, and amount deducted from the final account. One source of small expenses of this kind is the sprinkler installation which has to be brought up to date to suit every alteration or additional machine in the mill. The insurance inspector's report at each inspection determines this. Railway cartage rates and rebates for certain loads have all a bearing upon the profits of a mill. A mill, however carefully worked, cannot stand against careless or ill-considered buying of grain on dear markets, or parcels with which the cleaning department is not equipped to deal.

Summary of details required for one month's test in obtaining the costs and percentages in milling each sack of flour.

1. Total hours run.
2. Total sacks of flour made.
3. Total sacks of offal made.
4. Total weight and cost of fuel.
5. Total amount and cost of water used.
6. Total amount of cylinder oil.
7. Total amount of engine oil and grease.
8. Total waste and sundries.
9. Wages-bill, all departments.
10. Repairs bill.
11. Water, gas or electricity, and drainage charges.

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12. Incidental expenses, such as travellers' commissions, office and advertisements.
13. Depreciation on plant and buildings.
14. Insurance premiums (fire and other risks).

It is not within the scope of this book to deal with the actual costs of each item in practice. Many of these, indeed, vary so considerably that an average could scarcely be struck. It can be taken, however, that the total *power cost* averages about 3*d*. per sack of 280 lbs., and that the *totai cost* per sack varies from 1*s*. 3*d*. to 2*s*. 6*d*.

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CHAPTER XXVIII

RULES, REGULATIONS, AND ACCIDENTS

THE acts, applicable to most non-textile factories, apply with equal force to flour-mills. Although most are strictly enforced by inspectors, a few seem to be omitted or overlooked. This is especially the case with regard to the hours of labour. At various times agitators have put forward schemes for eight-hour days for operatives. This, for the continuous running of flour-mills, would mean three shifts per twenty-four-hour day. As a corresponding reduction of wages would probably result, the proposal has been most strenuously opposed by the operatives themselves. The twelve-hours' shift has been, and probably will continue to be, the rule for most mills. The main features of Acts applying to mills are all that can be given. Sanitary provisions state that from 250 to 400 cubic feet of air space must be provided for each person employed. A fine of £10 is imposed for allowing operatives to work in injurious or dangerous places and atmospheres. In the case of self-acting machines, travelling sections of the same must have clear working space. Within the mill laws are concerned with such matters as safe walking spaces and headroom, enclosed gears, securely guarded drives (where coming in the way of the working of the plant), fenced-in openings, sound trap-doors, employee's lifts (automatically stopping at the top floor), efficient guarding of any dangerous or moving machinery, fire-escapes and ladders, fireproof doors, ventilation, natural and artificial lighting, the careful and efficient collection of dust, and the isolation of any dust-rooms used, to obviate the risk of explosions and incidentally render the atmosphere more fit for human beings. All these are having special attention, and deservedly so, in view of the lamentable loss of life recently in mills from these causes. All these Acts, in their application to the power plant, lighting, manufacturing, and handling machinery, are framed with a view to safeguarding the interests of the mill

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operative and the private citizen. The Factory Act, the Truck Act, the Employers' Liability Act, all operate in favour of the working man, and rightly so, because he takes the greatest personal risks. They render the employer of labour open to many irksome and serious losses, but one fails to see how this can be avoided whilst doing justice to the operative. The laws governing the abatement of the smoke nuisance have operated to the final advantage of the miller, because they have been the means of evolving the form of fire-bar and the feed to the boiler furnaces, so that more of the fuel is consumed in them and in the flues, increasing the steam-raising capacity of the coal, whilst complying with the rules laid down as to smoke abatement. Automatic stokers have done much in this way. Bye-laws (local) respecting the escape of the grain and solid refuse into sewers, and other draining mediums, as evidenced by inspections at manholes, are rather severe, usually compelling millers to remedy such faults, however small. Any such refuse, and any hot water, steam, or waste discharging into docks or waterways, is at once challenged by the authorities. Now that electricity has come to play so large a part in the lighting and power economy of a mill, special regulations have been drafted out to meet the risks encountered. These mainly deal with the danger of fusing, short-circuiting, and shocks.

It will be seen that the liabilities and risks of losses are so many and so grave for millers that it is essential for them to take out some covering insurance policy against fire, accidents, etc., and thus safeguard themselves against crippling losses.

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CHAPTER XXIX

POWER AND POWER TRANSMISSION

BADLY worked mills lose as much as 25 per cent. in friction, whilst the well-equipped self-oiling mill loses 8–10 per cent. after the first year's running. Causes of wasted power are: (1) Source of power too far removed from the mill; (2) gearing and clutches; (3) slipping ropes; (4) short drives; (5) badly lubricated and worn bearings; (6) dirty and gritty oil or inferior quality; (7) too heavy or uneven feeds; (8) over-handling of stock; (9) changes in atmospheric conditions, and state of wheat; (10) badly-worn or "out-of-balance" machines.

A motor for driving a flour mill must give a uniform speed under varying loads; this the steam engine best meets. The reasons why gas engines are not more widely used are: (1) Liability to "sump" when called upon to start up on a cold mill, or to resume running after a bad choke; (2) necessity for a strong and reliable clutch between the engine drive and the first line shaft, engine to get up speed and be in perfect running before full load is taken; (3) the internal combustion action is not favourable to uniform speeds. A slight tendency to unsteady driving shows its speed fluctuations seriously upon the highly speeded machines in the mill. Electricity is a convenient means of transmitting power long distances. Under the best conditions a saving of 40–50 per cent. has been effected. Its great handiness in operating grain-handling and stock-handling machinery or in driving isolated warehouse machines is well-known and appreciated. For lighting, electricity is the most efficient, economical, and safe method. Water-power has been lost sight of to a large extent in England, due mainly to the low falls and uncertain supplies of water. Some time, at a far distant date, all water-power throughout the world will be at a premium.

Boilers for Steam Raising.—At present the steam engine and its attendant boilers are the power plant in most mills. In

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the Lancashire boiler (the popular type), made by Messrs. Galloway, the two furnace chambers connect into one at the end of the grates, which are continued to about two-fifths of the total length. The larger space obtained enables a number of cross-tubes to be fitted. This enables a large increase of valuable heating surface to be effected. The most useful size of Lancashire boiler is 30′ × 8′ diameter. The efficiency of the boiler, combined with the life and reliability, is the miller's first care. The figures given are the result of trials by Messrs. Galloway. The rates of combustion are based on good average results. The amounts given of water evaporated are based upon an evaporation of 8 lbs. of water per lb. of coal, a fairly high standard.

Size.	Heating surface.	Grate area.	Chimney, height in feet.	Coal.		Steam per hour.
				Burned per sq. foot Grate area.	Total per hour.	
Ft. In. Ft. Ins.	Sq. ft.	Sq. ft.				Lbs.
20 0 × 6 0	520	23½	100	20	465	3720
26 0 × 7 0	740	32	120	24	770	6160
28 0 × 7 6	870	35	150	28	980	7840
30 0 × 8 0	1000	38	180	32	1220	9760

A margin of about 15 per cent. is usually allowed for variations in coal.

In practice boiler-heating surfaces reduce the gases an average of 600° F. Assuming that coal will yield 13,500 heat units per lb., and that 24 lbs. of air are admitted for each pound consumed, 25 lbs. of gas will result. Each degree of temperature through which the 25 lbs. of gas are raised requires about 5·70 heat units. The number of heat units in flue gases having 600° F., the atmospheric temperature being 40° F., will be $(600-40)\times 5{\cdot}70=3192$, or 23 per cent. of the total heat produced. The loss can be diminished by installing economizers utilizing the waste heat to raise the feed-water temperature.

The economizer has the following advantages: (1) Saving of fuel and power first hand; (2) increase of boiler capacity; (3) saves repairs and lengthens the life of boiler by obviating the usual expansion and contraction of plates consequent upon sudden chills from cold feed-water; (4) less cleaning encrustation of the plates; (5) diminishing smoke nuisance.

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The tubes of the economizer are cleaned by automatically worked scrapers. A Lancashire boiler 30′ × 8′ diameter working at a pressure of 120 lbs. per square inch, and having a heating surface of about 1200 square feet, evaporates 800 gallons of water per hour. A suitable economizer would be one containing about 120 tubes. The available gases from such pressures and heats would raise the water in the economizer to about 260°–280°, and thus provide an economical feed to the boilers. Much difference of opinion exists as to the respective merits of hand and automatic stoking. A good stoker can humour the fires in a way that an automatic gear could not. Under the best conditions the latter shows to advantage, being more economical and obtaining a more perfect combustion. As a rule, specially prepared fuel must be used ; a uniform small size of coal being necessary if the delivery from the hoppers is to be reliable.

Steam Engines.—Mills up to twenty sacks mostly employ horizontal compound condensing engines, either slide valve or Corliss valve type. The cylinders are arranged either tandem or coupled. The larger mills use triple-expansion vertical engines. The pressures most in use for the vertical engine are about 180 lbs. with speeds of about 80 revolutions per minute. A useful size for medium plants, say a 30 sack, is a 15″, 24″, 36″ × 3′ 6″ stroke, 3-crank, vertical engine fitted with a surface condenser, this, at the speed and pressure just named, would give approximately 650 H.P. See Fig. 108 for a good illustration of this type of engine.

The flywheels of such engines are usually grooved for a number of ropes, radiating in the rope-race to all the main power shafts of the mill. The foundations should be deep and standing clear of the walls and floor of the engine-house, if possible, so as to render the inspection of any piping or foundation gear easier. All cylinders should be equipped with sensitive and reliable valves, operated and governed very exactly to meet fluctuations of power required, without noticeable alteration in speed. The engine should be automatically lubricated throughout. The wearing parts should be of ample surface, and the whole installation designed with good factors of safety, so as to secure minimum frictional resistance and noiseless running. Convenient access to all working parts must be secured by a system of platforms and stairs. The condensing plant should be free for inspection, cleaning, and repair, in all parts, so that any stoppage caused by impurities can be quickly removed, and serious and prolonged

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loss of power avoided. The engine should be completely equipped with all accessories for convenient handling and operating; the admission stop valve must be arranged for opening and closing the valve either from the top staging or

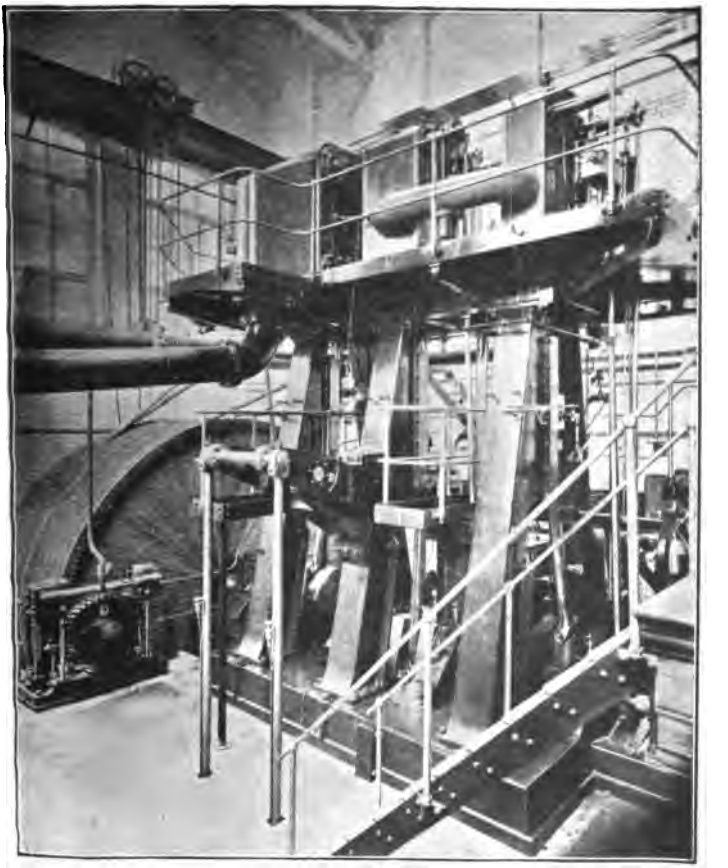

FIG. 108.—GALLOWAY VERTICAL ENGINE.

from the engine house floor. A good arrangement is that in which the engine can be stopped in case of accident, from the most prominent positions of the mill premises, by means of electric stop-motion connections.

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It is necessary in all steam plants to periodically obtain exact tabulated details as to the power developed on the engine to ascertain the power-cost for running the mill. An elementary method of calculating the horse-power of engines is by obtaining: (*a*) The speed of the piston in feet per minute; (*b*) the area of piston in inches; and (*c*) the mean pressure of steam in lbs. per square inch. Multiplying these three together and dividing by 1 H.P. in ft.-lbs., will give the desired result, thus $\frac{a \times b \times c}{33{,}000}$ = H.P. in cylinders. With engines of more than one cylinder, add the areas of the pistons together, and proceed in the calculations as in single cylinders. But the best method is to regularly indicate the work being done in the cylinders by obtaining indicator diagrams from these, with any standard apparatus. The power can be readily and accurately calculated from these diagrams. They also reveal the way in which the work is being done and the state of the valve gear.

Gas Engines.—Gas engines are not the most suitable for the absolutely unvarying speeds demanded by the mill. Great improvements are now in progress, and they will be used for electric generation supplying isolated motor units throughout an electrically operated flour mill. In a flour mill running night and day a gas engine should show appreciable net economies. A large modern gas engine will develop a brake horse-power on 10,000 B.TH.U. at full load. At three-quarters load the heat consumption per B.H.P. will be increased by about 12½ per cent., and at half about 35 per cent. One kilowatt is equal to 1·45 B.H.P. with a dynamo efficiency of 92 per cent. In calculating gas consumptions the lower or net heat value of the gas is always taken. This value averages about 90–110 B.TH.U. for blast furnace gas; 130–135 for Mond producer gas with ammonia recovery; 135–140 for Mond gas without recovery; and about 400–550 for coke-oven gas. The fuel consumption of a large gas engine is about 60 per cent. of that of a corresponding high-class steam engine and steam plant. The oil consumption for lubrication is greater, and the repair bill also. The capital cost is considerably higher; so that when all these charges have been taken into account the gas plant and the steam plant for mills are about equally economical in total cost, with coal at about 10s. per ton.

Electric Motors.—The three types now in use are: (1)

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The "Shunt Wound"; (2) the "Series Wound"; and (3) the "Compound Wound." The "shunt" has its magnet spools with many turns of fine wire connected across the mains. The speed of this type is constant under nearly all loads—a great advantage for milling machines and drives. It is not suitable, however, for heavy overloads, which are liable to heat the windings unduly. The "series" wound motor has its magnet spools wound with comparatively few turns of thick wire joined in series with the armature. The speed varies greatly with any alteration to the load, but it has great power in dealing with heavy overloads of short duration. The "compound" is a mixture of "shunt" and "series." It is mostly employed where the work varies from no-load to overload, and where perfect governing is not essential. The great objection to motors is the tendency to overheat. A strong and continuous current of air must always be passing through the machine to obviate this. A mill with all the dust present renders this dangerous in the event of sparking at the brushes and the commutator. The semi-enclosed or ventilated type of motor is usually employed, which mitigates, although it does not overcome this danger. It is the medium between an open motor, freely ventilated and dangerous in the presence of dust, and the enclosed type always overheating. Every motor should have an output plate, on which is recorded the speed, horse-power, volts, pressure, and current for which it is made. It is of the first importance that all parts should be kept clean. Periodic examination of all internal parts should be made, and any dirt attached removed. Keep the lubrication perfectly clean and ample, but do not allow oil inside the motor or dynamo, or upon the cables, as it is apt to rot them. Keep the machines firmly fixed and the brushes bearing evenly against the commutator. If worn unevenly renew at once. Sparking, one of the worst troubles of dynamos and motors, may be caused by several things. Commonly it is the uneven bearing surfaces just referred to, which have this bad effect. Badly worn bearings will cause it. Excessive vibration from uneven running or driving will constantly jar sparks out. Excessive overloads have the same effect. Steady running depends a good deal upon the position of the belt drive in the case of a motor or dynamo. In the latter especially it is essential that, with the belt driving tight side beneath, the angle of the top side should be as nearly horizontal as possible, so

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that the downward travelling slack side should not override the small dynamo pulley. Special rules have been issued by the Fire Offices Committee relating to the use of motors in flour mills. The chief clause relates to the necessity for totally or partially enclosed motors. The latter must be covered at the ventilating holes by two thicknesses of approved wire gauze.

Electric motors must be controlled by means of an efficient cut-off switch, placed in a handy position. Efficient fuses, or other automatic cut-outs, must be provided. A notice must be fixed in a conspicuous position at every motor and switchboard in connection with the supply, forbidding unauthorized persons to touch the motors or apparatus.

All motors and electrical apparatus must be kept carefully dry, dampness being fatal to good work or long life. The cost of production and rates of supply vary considerably. A few mills in this country are driven throughout by electric motors, the current either self-generated or obtained from corporation or company power-stations. The usual plan followed is to drive the main shafts by motors either direct coupled or connected by belt. By attaching a suitable recording meter to each of these power units the exact fluctuation of electrical power can be ascertained. Statistics can be made of the difference required in working various wheat mixtures, and the variations following upon newly-grooved rolls or finely-covered dressers. Atmospheric changes can also be checked in their relationship to the power absorbed. It is possible also with electric motors to so scheme the gearing down to the normal mill shaft speeds, that change-speed-gears will allow the maximum speed (and maximum power therefore) of the motor to be attained, before the full drag of the mill is thrown upon it. Records of mill power absorption under all conditions can thus, in the case of electric driving, be brought down to an exact science.

POWER UNITS.

Electrical.

1 horse-power (H.P.)	= 746 watts.
1 kilowatt	= 1000 watts.
1 kilowatt	= 1·34 H.P.
1 Board of Trade (B.O.T.) unit .	= 1000 watt-hours.
1 ,, ,, ,, ,, .	= 2,653,800 foot-lbs.
1 ,, ,, ,, ,, .	= 1·34 H.P. hour.
1 horse-power (H.P.)	= 33,000 foot-lbs.

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Water Power.—The comparative powers available from the several types of water-wheels are:

Undershot	30–40 per cent.
Low Breast	45–60 ,,
High Breast	50–65 ,,
Overshot	60–65 ,,
Turbine	70–83 ,,

The turbine is easily first in efficiency. The best application of such power is in the generation of electricity. The future will probably see the greater amount of available water power applied in this way. It is possible to transmit such power a considerable distance without much loss or undue expense. Many sources of water power are now of much value, which formerly were almost useless on account of their isolated position.

Before commencing to harness the power of a stream or fall, a certain amount of data must be collected, in order to ascertain the available force of water passing the fluctuations of head, due to either a diminished head water, in dry seasons, or a deepened tail race in wet seasons. The available "water H.P." equals *weight passing per minute* × *head* (*in feet*).

A method of obtaining the flow and quantity of water available is by measuring it at a weir or notch board. The water should be dammed back until it is as still as a reservoir, having little or no sensible velocity of motion, until it approaches the overflow. The width can be taken. The depth must be measured, not on the edge, but some distance back from weir before the water begins to curve downwards.

The actual horse-power available in the mill or on the shafting is reduced to about a 75 per cent. efficiency.

Water and Other Measures.

1 cubic foot water = 6·25 gallons = 28·3 litres.
1 ,, ,, ,, weighs 62·5 lbs.
1 cubic metre of water = 1000 litres = 1000 kilos = 35·32 cubic feet = 220 gallons.
1 metre = 39·37 inches = 3·28 feet.
1 gallon of water weighs 10 lbs.
1 ,, ,, = 0·16 cubic foot = 4·543 litres.
Cubic feet per minute × 0·472 = litres per second.
Pressure in lbs. per sq. inch = head of water in feet × 0·433.
,, ,, ,, × 2·31 = head of water in feet causing such pressure.
1 horse-power (H.P.) = 33,000 ft.-lbs. per minute = 550 ft.-lbs. per second.

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Water flowing through a pipe at 3 feet per second delivers approximate quantity cubic feet per minute equal to diameter of pipe in inches squared. Thus, 12-inch pipe delivers $12 \times 12 = 144$ cubic feet.

The power required for driving complete flour mill installations, working under normal conditions, totals 14 H.P. per sack, divided into 4–5 H.P. per sack on the wheat cleaning and handling plant, and 9–10 H.P. per sack on the milling section. In very large mills the grain handling plant working over large areas takes additional power, difficult to average, as it varies greatly with each scheme.

In the flour mill the power is divided approximately thus: 24 per cent. on breaks, 36 per cent. on reductions, 21 per cent. on dressers (if centrifugals and reels), 15 per cent. (if plansifters), 7 per cent. purifiers, 6 per cent. shafting, and the remainder on fans, conveyors, and elevators. It is becoming the practice to install quite a number of fans for thoroughly aspirating and exhausting practically every machine in the mill. These, of course, take extra power, but this does not add much, if any, to the sum total required, because it is partly balanced by the correspondingly easier running of all the machines.

The leather belt can be used for straight, crossed, or open, quarter-twist, or angular driving, with ease and reliability if the plain laws regarding each are followed. In main driving leather belts the joint is made whilst the belt is in its place, and it should present the appearance of an endless belt.

The best test for any belt drive is a non-slipping slack belt. Flexibility is the best way to ensure this. The fleshy side of the belt should run next the pulley face. The trouble of flour-mill drives, especially those on purifier and dresser floors, is that of dust accumulations. It gradually gathers into lumps, and spoils the driving contact. Badly-lubricated bearings are often the cause of belts leaving the pulleys. The shaft heats and "seizes," requiring such abnormal power to turn at the normal speed that the belt slips, overrides and quickly comes off the driving face.

Belt fasteners can be had in large varieties and sizes. In order of horse-power to be transmitted, it is usual to place the large plate first, riveted in the butt-joint. The next form of fastener for heavy belts is the well-made butt-joint, with lace holes punched in a row of diamond shape is a good

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method. Care should be taken that the holes do not come in line across the belt. The strands of the lace should run lengthways of the driving side of the belt, for a good long life. Lap-joints should be very carefully pared away to a fine edge so that no knocking occurs in running. On individual machine drives it is usual to employ the common Harris belt fasteners, especially as the belts keep to about 4-inch wide limit. In theory, laces are always to be preferred to these hammered-on connections, but in practice, these latter on good sound leather, well preserved, do excellent work. There are many other types of metal fasteners, some especially suitable for awkward cases. Crossed drives are frequently used in a mill, with a good deal of trouble. If, however, the joint is made very carefully, and the pulleys are truly set so that no whipping of the belt occurs, these will be almost as long-lived as a good open drive. Quarter-twist drives require humouring to start.

Strengths and Powers of Belting.—A good many tables of belt powers have been worked out, but have not always proved successful or reliable, because the basis of calculation changes with every size and speed of pulley. Messrs. John Tullis & Son, the well-known leather belt experts, state that a safe working strain for a single belt is approximately 50 lbs. per inch of width, and for a double belt approximately 80 lbs. That one horse-power is safely transmitted per inch of width by a single belt running at 800 feet per minute on a 48-inch pulley—or by a double belt running 500 feet per minute on a 48-inch pulley. Belts should be run with the slack side above, the taut or driving side beneath. By this means the maximum of grip is obtained. High speeds over small pulleys are wasteful and produce unsteady drives.

When a belt breaks from fair strain, the rupture is straight across the weakest part. When it breaks diagonally across solid leather it has been torn by accident. To find the length of a roll of belting: Take the overall diameter and add the diameter of hole in the centre of roll, divide the sum by two. Find mean diameter, and multiply by 3·1416 ($\frac{22}{7}$). This will give the circumference. Multiply this by the number of laps. This gives *length in inches*. Divide by 12 for length in feet. Thus, for example, we have a roll of $\frac{1}{8}$-inch belting, 4 inches wide, outside diameter, 2 feet 6 inches, inside hole 1 foot diameter.

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$$\text{The mean diameter} = \frac{2' 6'' + 1' 0''}{2} = 1' 9''$$

$$\text{The circumference} = 1{\cdot}75 \times 3{\cdot}1416 = 5{\cdot}5$$

$$\text{Length in feet} = 5{\cdot}5 \times 6 \left(\frac{\text{laps}}{12}\right) = 33 \text{ feet.}$$

Transmission of power by ropes is one of the most economical of all methods. It is flexible and will take any sudden strain or shock without damage or great inconvenience. It is practically positive in transmitting power from pulley to pulley. The loss of power in rope driving is from 2·5 to 3·5 per cent. If a rope gives way it can usually be removed and the remaining ropes take the extra work and strain, being temporarily overloaded, until the damage can be made good.

Where a rope is continually subjected to excessive driving pulls, it is liable to either " wedge," that is, jamb between its V-shaped pulley grooves, or to diminish in diameter and run in the bottom of groove. A moderate tension, one found by long experience to be most suitable, will leave the rope in the correct position at the upper half of groove. It will retain its shape and strength for years and give practically no trouble. New ropes should be a full fit so that the final " set," or slight reduction in diameter, will leave them as just indicated. Any " surging " or bouncing on the part of a rope is often due to the uneven running of the engine. Ropes should be run on pulleys not less than 30 times their diameter. The best speed has been found to be 4800 feet per minute. A reference to the table attached, by the kind permission of Messrs. Thomas Hart, maker of the Lambeth Cotton Driving Rope, will show a steadily diminishing driving capacity both above and below that speed. The usual working tension is 200 lbs. per square inch of sectional area, and equals one hundred and sixty times the square of the rope diameter. Long drives, from 60 to 90 feet centres, and on pulleys say of 6-foot maximum diameter, running at an angle of 45° give good results and last for years.

Drives are best arranged with the slack side at the top. The rope has more circumferential grip than in the case of a slack bottom rope. When fixing new ropes, the splicer must use his own judgment as to the safe tightness of the ropes, from a consideration of the strength of shafts and bearings. All ropes should be periodically lubricated by some reliable composition, which does not " perish " its structure, but tends to feed it. Well-tried anti-fraying compositions for rope lubricants are best.

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Ropes, Pulleys, and Horse-Power for Speeds.

"Lambeth" ropes.

Dia. rope in inches .		¾	1	1¼	1⅜	1½	1⅝	1¾	1⅞	2
Dia. rope in mm. .		19	25	32½	35	37½	40	44	47	50
Circumference rope in inches		2·35	3·14	3·92	4·31	4·71	5·10	5·50	5·89	6·28
Circumference rope in mm.		60	78½	102	110	118	125	138	147	157
Weight per yd. lbs. .		9 oz.	15 ozs.	1 lb. 7½ oz.	1 lb. 12 oz.	2 lb. 0 oz.	2 lb. 4 oz.	2 lb. 10 oz.	3 lb. 0 oz.	3 lb. 6 oz.
Smallest size pulley advisable in feet		1′ 8″	2′ 6″	3′ 0″	3′ 4″	3′ 9″	4′ 1″	4′ 5″	4′ 9″	5′ 0″
Ditto in metres . .		0·5	0·75	0·9	1·0	1·15	1·24	1·37	1·44	1·52
Horse-power per rope										
Feet per min.	Metres per min.									
1000	304	2·5	4·5	7·1	8·6	10·2	12·0	14·0	16·1	18·2
2000	609	5·1	9·1	14·2	17·3	20·5	24·1	28·0	32·2	36·5
3000	914	7·1	12·6	19·8	23·9	28·4	33·3	38·7	44·5	50·4
4000	1219	8·4	14·8	23·2	28·1	33·4	39·2	45·5	52·4	59·4
5000	1523	8·7	15·4	24·1	29·1	34·6	40·6	47·1	54·3	61·5

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Brief summary of advantages of rope transmission for main drives—

(1) In first cost and in renewals, rope driving cheaper than any other driving mediums.

(2) Saving in driving space.

(3) Freedom to drive shafts at almost any desired distance apart, and with almost any variation of speed.

(4) Slipping reduced to a minimum, easier distribution of power.

(5) Elasticity, adding to the safety of driving, thus preventing stoppages.

(6) Lighter running, less noise and more positive drive than other systems.

(7) The loss of a rope temporarily, through breakage or necessary overhaul, will not seriously interfere with power transmission; remaining ropes will take extra strain safely for a time.

(8) Freedom from such breakdowns for long periods under normal conditions.

HORSE-POWER OF COTTON DRIVING ROPES.[1]

Velocity in feet per minute.	¾"	1"	1¼"	1⅜"	1½"	1⅝"	1¾"	1⅞"	2"
1000	2·5	4·5	7·1	8·6	10·2	12·0	14·0	16·1	18·2
1500	3·7	6·7	10·6	12·9	15·3	18·0	21·0	24·0	27·1
2000	5·1	9·1	14·2	17·3	20·5	24·1	28·0	32·2	36·5
2500	6·2	11·0	17·2	20·8	24·7	29·0	33·7	38·9	44·0
3000	7·1	12·6	19·8	23·9	28·4	33·3	38·7	44·5	50·4
3500	7·8	13·9	21·8	26·4	31·4	36·8	42·8	49·3	55·8
4000	8·4	14·8	23·2	28·1	33·4	39·2	45·5	52·4	59·4
4500	8·7	15·3	24·0	29·0	34·5	40·5	47·0	54·2	61·4
4600	8·7	15·4	24·1	29·1	34·6	40·6	47·1	54·3	61·5
[2]**4800**	**8·7**	**15·4**	**24·2**	**29·2**	**34·7**	**40·8**	**47·3**	**54·5**	**61·7**
5000	8·7	15·4	24·1	29·1	34·6	40·6	47·1	54·3	61·5
5200	8·6	15·2	23·9	28·8	34·3	40·2	46·7	53·8	61·0
5400	8·5	15·0	23·5	28·4	33·8	39·6	46·0	53·0	60·0
5500	8·4	14·8	23·2	28·1	33·4	29·2	45·5	52·5	59·4

Power—Horse-Power for Shafting.—A ready rule for roughly calculating the horse-power available from shafting is that it equals $\frac{\text{Dia.}^3 \times \text{Revs.}}{80}$, thus a 2-inch shaft at 120 revolutions gives approximately $\frac{2 \times 2 \times 2 \times 120}{80} = 12$ H.P.

[1] The "Lambeth" make.

[2] The best speed for practice.

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The following table, although it does not meet all cases, will be found serviceable for general purposes:—

Inch dia. shaft	Revolutions per minute.												
	100	120	150	180	200	220	250	280	300	320	350	400	
1½	4	5	6	7·5	8·5	9·25	10·5	11·75	12·5	13·5	15	17·5	H.P.
1¾	6·5	8	10	12	13·5	14·75	16·75	18·75	20	21·5	23·5	27	,,
2	10	12	15	18	20	22	25	28	30	32	35	39	,,
2¼	14	17	21	25·5	28·5	31	35·5	39·75	42·5	45·5	50	56	,,
2½	19·5	23·5	29	35	39	43	49	54	58·5	62·5	68	78	,,
2¾	26	31	39	47	52	57	65	73	78	83	91	103	,,
3	33	40	50	60	67	75	84	94	100	108	118	135	,,
3¼	42	51	64	77	86	95	107	120	129	138	150	172	,,
3½	53	62	80	95	106	115	132	148	160	170	185	212	,,
4	80	96	120	144	160	176	200	224	240	256	280	320	,,

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CHAPTER XXX

FIRE RISKS AND SAFEGUARDS—MILL LIGHTING

FIRE risks and explosion risks, in flour mills, are such that careful and efficient precautions are an absolute necessity. Besides the sprinkler installations now in wide use it is advisable to take other safeguards, especially in regard to the dust question. Absolute cleanliness in all parts and machines is of the first importance in reducing fire and explosion risks to a minimum. Insurance companies allow such substantial reductions on the insurance premiums for sprinklered buildings as against non-sprinklered premises, that it always pays to have them installed upon that count alone.

Amounts allowed range from 25 to 50 per cent.

All millers must comply with certain regulations laid down by the Fire Offices Committee when installing an automatic sprinkler plant. Every portion of a building, and all communicating therewith or adjoining, but without a party wall carried right up to the roof, must be protected by sprinklers. Silos or grain bins within a building are exempt, mainly because the wheat forms a solid wall against which, if left intact, fire would rage without much headway, and also because water from, say, a damaged sprinkler-head, would cause very serious risks to the mill structure by the swelling of wet grain in bulk. It is usual to sprinkler and rate the wheat-cleaning, mill, and warehouse separately, and to leave the intake and silos unprotected.

The main rules are: (1) The town's main must give a minimum pressure of 10 lbs. at the highest sprinkler; (2) the gravity or elevated tank, supplying the whole system of sprinklers, must be of 5000 gallons minimum capacity, according to the number of heads. It must be placed 15 feet above the highest sprinkler to ensure sufficient pressure, thus giving approximately 7 lbs. per square inch for the minimum. The greatest number of heads allowed usually under one control or supply is 150; (3) the pressure or compressed air-tank must

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be installed where it is not practicable to erect a sprinkler tank and tower above the highest point of the building. These tanks are partly filled with water, the necessary pressure or "head" being imparted to them by means of compressed air, which is maintained in the empty portion of tank by an air-pump. It should hold 3300 gallons of water when partly filled, as described, and should give 45 lbs. pressure to the highest sprinkler head. For either type of tank, pumps usually, duplex steam, and other injector apparatus of approved pattern must be provided.

A sprinkler installation is not designed to cope with a fully-developed fire. The popular form of fire-fighter, the fireman's hose, is only necessary, because in such cases the whole, or part of building, is already involved. To let a fire get a strong hold, and then by means of violent forces of water to *drive* or thresh it out, is bad policy.

FIG. 109.—MATHER AND PLATT'S SPRINKLER HEADS.

The "Grinnell" Sprinkler by Messrs. Mather & Platt is a well-known and widely used type, and will serve as a good example of its kind, see Fig. 109. It is of the valve type, and can be fixed either vertical or inverted. The valve is held in place, closing the water outlet nozzle, of a flexible diaphragm, by means of a metal tongue or strut soldered to a small bracket. This solder joint is the only thing which keeps the strut in position. Under normal conditions the solder is designed to soften and melt at about 150° F., and in specially hot places, such as above boiler flues, a form of solder is used which does not soften until a temperature of 200–220° F. is reached. These latter sprinklers are termed "corro-proof." In either type of head, directly the strut, bracket, and valve fall away, the released water, a ½-inch stream, with the pressure behind it, impinges directly upon the deflector, and is broken up into a wide-flung shower. The sprinkler-heads are so placed that the shower from one intermingles with that of its neighbour, covering the floor. The valve is of glass, and the flexible diaphragm seat is of German silver, giving 200 lbs. tension, thus preventing the possibility of either leakage of water, adhesion, or corrosion. The floor space per sprinkler head is

64 square feet, or if in bays, each bay must not exceed 8 feet. At least one sprinkler-head must be provided to each elevator head, placed to command both legs. One must be placed at the head of each dust trunk or spout, inside dust-trunk connected to fan, on delivery side. All wood or other combustible material in trunks over 30° out of the perpendicular to be protected by sprinklers, maximum, 10 feet apart. All hoists, elevators, shoots, rope and strap races, machines placed two-high, gearing boxes and non-fireproof staircases and concealed spaces to be sprinklered.

Every sprinkler must be examined at least once a week and all dust and other accumulation removed therefrom. (It is to be feared that this latter rule is more honoured in the breach than in the observance.) Every installation must be fitted with an automatic alarm signal, to give notice of any sprinkler opened.

Ordinary appliances are intended as an addition to, and *not* a substitute for, other fire-fighting appliances, which must be provided in accordance with requirements, and maintained in thorough working order.

These include the following items. Buckets filled with water, on each floor. (Hand grenades are a better substitute in most cases.) Electric light throughout the mill, cables and wires being kept dry. Periodic overhauling of whatever constitutes the principal safeguard against fire. No naked lights. Isolated dust or screen room. No matches or smoking on the premises. No heated bearings. Scrupulous cleanliness everywhere, no heaps of refuse in dark corners, no dripping oil on grain or dust or flour heaps, likely to cause spontaneous combustion. All windows closed down when not working, to minimize draughts.

Lighting of Mills—In planning the buildings for each section of the milling processes, as much daylight should be introduced as possible. Such lighting means better ventilated and more healthy atmospheres. It is an incentive to cleanliness and more efficient work. Vermin always breed faster in dark and foul places. Stocks of all kinds can be better handled and better judged in strong daylight. Such schemes reduce the artificial light bill. In dealing with the question of artificial light, fire risks, cost of installing, cost of upkeep, efficiency and freedom from break-down are the most serious. The fire insurance companies have had a great deal to do in evolving a safe and efficient light in mills.

"Premiums" have been the magic lever. Whilst a number of mills still use gas, by far the greater part use electricity. Except in cases of incompetent fixing and short-circuiting there is little danger of fire. It is not dangerous in the presence of dust and other inflammable particles. Strong draughts do not affect it. In arranging for lighting it is important to consider the purposes for which the light is required, and to distribute it so as to provide efficient and economical illumination. Three 8-candle-power lamps will be sufficient to light 100 superficial feet of floor surface, placed 7 feet 6 inches above it, for the mill, and two per 100 feet for the warehouse. If placed higher than this, more lamps, or some of greater power, will be necessary. It takes a 16-candle-power lamp to illuminate 100 feet of floor at 12 feet above. Incandescent lights are worked at various voltages, from 150 to 250 being common practice. The life of the usual lamps is about 600 hours. Sudden bursts of current, liable to burn away the delicate filament of the lamp, must be met by the insertion of suitable fuses in the cables leading the electric supply.

An electric lamp of 3½ watts per candle-power efficiency (a usual standard) would consume 56 watts of electrical energy for a 16 candle-power light per hour. Where large installations are close at hand, it pays the miller usually to take his lighting current from them, but in small stations where the rates are, say, 2½*d.* to 3*d.* per unit, it pays to install a generating plant in the mill power house and driven from the prime movers. The actual cost of fuel for producing the current will be about 1¼*d.* per unit, plus cost of attendance, wear and depreciation of plant, etc. The engine-room attendant will usually do the first section, so that it can be eliminated from most plants. As such lighting will be periodically required when engine is standing, an accumulator storage will be necessary for a sufficient surplus to meet such needs.

Lighting from central station can be obtained by several methods :—

(1) By direct current distribution on the two-wire system.

(2) By direct current distribution on the three-wire system.

(3) By direct current distribution on battery and transformer system.

(4) By alternating current on a transformer system.

The main rules to follow when wiring for electric lights are, that in places where inflammable or explosive gases, dust, or vapour are liable to be present, dynamos, arc lamps,

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Nernst lamps and plug connectors must not be used. In such situations incandescent lamps must, with their holders, be enclosed in an air-tight fitting of thick glass; switches, fuses, and resistances must be enclosed in gas-tight boxes, or break under oil. It is better still, where possible, to place all such connections outside such zones of danger. The motors, with their live parts, starters, terminals, and connections, must be completely enclosed in a flame-tight casing made of fire-proof material. Except where completely enclosed in a metallic casing, no switch, ceiling rose, cut-out plug, connector or other electrical accessory may be mounted directly upon any surface liable to become damp, but must, in addition to its own mount, be fixed upon a base-block rendered impervious to moisture.

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CHAPTER XXXI

CAPACITIES AND SPEEDS OF MACHINES

THIS section is necessary both to the student and to the practical miller. Milling engineers are only too willing to supply all such data applying to their own particular system. The particulars are collected into one section.

Whilst the information supplied is as comprehensive as possible, owing to the limited space, it is impossible to include all the makers. Particulars are taken from the latest catalogues kindly placed at the author's disposal just before going to print.

From the following lists it is possible to deduce the average speeds (in revolutions per minute) of the various average machines. The table for handy reference would be as follows :—

DRY-CLEANING MACHINES.

Elevators—(ship and standing, wheat)	300–350
Elevators—flour	180–250
Rubble reels	75 average
Wheat worms	100
Wheat bands	480–550 ft.-min.
Double receiving warehouse separators	350–500
Zigzag or milling separators	550–600
Wheat aspirators	750 fan.
Driving pulley	190
Horizontal scourers	450 average
,, brushes	450 ,,
Vertical brushes	500
Barley cylinders	14
Cockle cylinders	14
Magnetic separators and feed dividers	35–40
Dry stoners	110
Wheat mixers or measures	35
Rotary grader	170
Multitubular dust collector worms	60
Exhaust fans	750

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WASHING AND CONDITIONING MACHINES.

Pulsating wheat washers	180
Wheat washers (inclined worms in tank)	100
Wheat whizzers	450–500
Wheat steaming worm	75

FLOUR-MAKING MACHINES.

Millstones (48 inches diameter)	140
Diagonal four-roller mill (10 inches diameter)	
Breaks, gears 2½ to 1, fast roll	350
Reductions, gears 5 to 4, fast roll	220
Bran rolls, gears (15–18 inches diameter)	150–180
Scratch rolls, gears 2½–3 to 1	210–245
Cyclo-pneumatic separator	200
Rotary sieve scalper	350–400
Plansifters	180–190
Hexagonal reels	35
Inter-elevator reels	28–45
Sifters (reciprocating)	500
Centrifugal bran-dusters	350–400
Centrifugal flour-dressers	185–260
Detachers	200–350
Grinders ("Dreadnought" type)	450–800
Sieve purifiers	500
Exhaust fans	500–1000
Flour and offal feeders	50
Automatic flour packer	150
Automatic bran packer	140
Sack hoists	300
Employees' lifts	1–2 ft. per sec.
Sack-cleaning machine	250
Roll grinding and fluting machine	180

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Machines by Messrs. Henry Simon, Ltd., Mount Street, Manchester.

Machine. "Reform" and "Simon" series.	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity Bushels per hour. Smallest and largest.	Driving pulley. Revolutions per minute.	Size.
	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Dry Wheat Cleaning Machines—							
Warehouse and receiving separator	5 1 10 2	4 1 8 7	5 7 8 10	3 single 5 double	50–100 1200–2500	350 350	7×4 14×7
"Simon" wheat aspirator	4 8 8 0	3 8 8 0	4 6 7 6	5	30 550	750 1200	7×5 9×6
"Simon" wheat separator	9 4½ 10 2	4 10 6 8	7 3 7 5	2	120 240	300 300	12×4½ 15×5
"Reform" emery scourer	5 5 9 0	3 4 4 8	5 1 7 3	6	20 130	575 300	14×5 20×7
"Reform" vertical brush	4 8 4 10	4 2 4 4	7 3 10 10	4	30 150	500 450	10×6 14×7
Trieur cockle and barley cylinders	4′ 2″ × 14″ dia. 7′ 6″ × 22″ dia.			5	5 cockle, 3 barley 30 ,, 20 ,,	— —	— —
"Record" cockle machine	5 3 13 2	4 2 5 3	4 8 5 3	2 single 2 double	46 184	250–260 210–220	10×2½ 10×2¾
Cyclone dust collector	3′ 6″ dia 10′ 0″ ,,	3 9 10 3	5 8 16 6	10	8×8 trunk 24×36 ,,	— —	— —
"Exact" wheat measuring machine	2 7½ 2 8	1 5 1 5½	1 4 1 4	1 single 1 double	400 400	5–35 3–35	— —
"Reform" pressure filter dust collector	40 cubic feet. 224 ,, ,,			15	16 sleeves 324 ,,	— —	— —

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MACHINES BY MESSRS. HENRY SIMON, LTD., MOUNT STREET, MANCHESTER (*continued*).

Machine. "Reform" and "Simon" series.	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity. Bushels per hour. Smallest and largest.	Driving pulley. Revolutions per minute.	Size.
	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Wheat Washing Machines—							
"Simon" wheat washer and stoner	10 5 12 0	4 0 6 6	7 3 7 8	3	80 200	180 180	20×5 24×5
"Manchester" concentric wheat stoner	2 6 2 11	dia. "	4 9 5 5	2	60 100	— —	— —
"Manchester" wheat washer, stoner, and rinser	8 0 8 6	2 6 2 10	4 9 5 6	2	40 72	200 200	12×3 12×3
"Simon" ventilated vertical whizzer	2 9 4 6	dia. "	6 2 8 8	4	32 240	— —	10×6 18×7
Mumford patent— "Reform" combined washer, stoner, and whizzer	10 6 11 0	3 9 4 3	8 9 8 6	2	170 240	155 165	16×7 18×7
Water-wheel damper	3 6	2 0	2 10	1	40–200	—	—
Wheat Conditioning Machines—							
"Simon" wheat-drying, cooling, and conditioning machine	—	—	—		4 single 4 double 4 triple 4 quadruple	60 240	— —	— —
"Reform" wheat-drying, cooling, and conditioning machine	2 3 2 3	2 0 2 0	12 0 20 3	2	40 80	— —	— —
Automatic wheat steamer	0 10 0 13	dia. "	0 26 0 34	3	20 50	— —	— —

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Flour-making Machines—										
								Breaks.	Reductions.	Breaks.	Reductions.
"Reform" patent four-roller mill	16×9	5 3	3 8	3 7	14	—		375	225	16×5½	20×5½
	40×10	7 9	4 2	4 1				350	210	,,	,,
	60×10	9 6	4 2	4 1				350	—	20×6¼	—
	40×14	7 10	4 5	4 1				—	180	—	24×6¼
"Simon" rotary plane scalper		6 0	2 1	4 0	5	—		150		12×4	
		10 0	5 10	5 0				150		14×4½	
"Simon" double-horizontal centrifugal scalper		12 6	2 8	4 3	3 dias.	20", 25", and 30" diameter		250		12×4½	
		14 4	3 4	5 0 (3 shts.)				200		14×4¾	
Reels		8 0	3 8	5 3	34" dia.	2, 3, and 4 shts.		—		30×4	
		15 0	3 8	5 3						30×4½	
Oscillating sieves		7 3	3 4	2 9	3	4′ 8″×2′ 1″ sieve		500		8×3	
		10 0	2 11	1 9		8′ 0″×2′ 1″ ,,		500		8×3	
"Reform" plansifter		7 2½	4 3	3 8	11	5–8 sieves		175–180		16×4	
		7 2½	6 10½	4 4½						19×4¾	
"Simon" dustless purifier		8 5	2 10	6 5	1 single	—		450		8×3	
		10 9	5 8	6 11	2 double	—		450		8×4	
"Reform" M. Q. purifier		9 4	4 0	5 1	3 single	Sieves 12", 15", and 18" wide		450		8×4	
		9 4	6 7	5 1	3 double					8×4	
"Simon" centrifugal dresser		10 8	2 8	4 4 (2 shts.)	3 dias.	20", 25" and 30" dia., 2, 2½, and 3 sheets		250		12×4½	
		14 1	3 4	5 0 (3 shts.)				200		14×4¾	
"Reform" suction filter dust collector		—	—	—	8	—		—		—	
Flour and offal possers		—	—	—	—	—		—		—	
"Star" sack cleaner		5 0	8 6	10 7	3	100–300 sacks.		—		36×6¾	
		9 0	8 6	10 7						36×6¾	
Universal grinder		0 6½	0 21¼	0 44	3	—		800		10×6	
		0 94	0 40	0 64				460		20×9½	

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Machines by Messrs. Thomas Robinson and Sons, Rochdale.

Machine. (R)	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity. Bushels per hour. Smallest and largest.	Driving pulley. Revolutions per minute.	Size.
	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Dry Wheat Cleaning Machines—							
Double-receiving separator	8 6 / 10 6	5 4 / 9 5	6 11 / 8 2	6	100–300 / 1500–4000	550 / 500	8×4½ / 16×5
Zigzag milling separator	5 0 / 7 3	5 9 / 8 2	6 3 / 9 1	5	20–35 / 200–250	560 / 520	7×4½ / 10×6½
Receiving and dusting reel	9 10 / 11 4	4 0 / 4 0	5′ 4″ (2 & 2½ shts.) / 5′ 4″ × 30″	2	448 / 660	54 / 54	18×4½ / 18×4½
Wheat aspirator	3 6 / 5 0	2 0 / 3 0	3 2 / 4 7	3	83 / 250	(190) 500 fan / (190) 500 „	(5×2) 6×4 / (5×2) 10×5
					Cockle. Oats and Barley.		
Barley and cockle cylinders	14″ dia. × 4′ 1″ / 32″ dia. × 9′ 10″			8	7–8 4–5 / 73–4 47–8	20 / 10¼	— / —
Pea separating cylinder	6′ 0″ × 12″ dia.			1	23	16	6×2½
Wheat grading and separating reel	10 0 / 14 0	4 0 / 4 0	6′ 0″ (36″ × 8′) / 6′ 0″ (36″ × 12′)	3	120–150 / 200–220	69	33×5½
Combined scourer, aspirator and separator	8 2 / 10 6	3 10 / 5 0	7 4 / 9 9	4	80–100 / 240	500 / 350	12×6 / 15×7½
Ditto. Smaller size	6 9 / 7 10	2 6 / 3 2	5 6 / 6 7	3	20–30 / 40–60	700 / 550	9×4 / 9×6
Emery grain scourer	8 5 / 11 0	2 11 / 4 3	5 0 / 8 10	7	20–30 / 240	500 / 350	9×4 / 18×6

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Combined milling separator and scourer	6 9 7 10	3 6 4 2	6 1 7 2	3	20–30 40–60	700 550	9×4 9×6
Horizontal wheat brush	7 0 10 6	3 9 5 0	7 0 8 9	4	80–100 240	400 350	12×6 15×7½
Ditto. Smaller	6 9 7 0	2 6 3 2	5 5 5 9	3	20–30 40–60	700 500	9×4 9×6
Dry stoning separator	6 4¾ 10 0	5 11 6 0¾	4 0 4 4	11	Approx. 37 ,, 147	108–112	—
					Each compt.		
Moir's wheat mixer and feeder—Single and double	2 4 3 8	S. D. 1 2 2 1 3 0 4 11	1 0 1 8	7 S. & D.	31 550	35 35	— —
					Each compt.		
Wheat measurer	1 9 1 11	2 3 1 6	1 5 1 7½	2 single 2 double	50 110	25 25	8×2½ 8×2½
Magnetic separator and feed divider	2 9 5 11	2 0 2 0	2 7½ 2 7½	8	25–40 270–300	36 36	6×2½ 6×2½
Exhaust fan	2 5 10 8	3 2 9 6	2 5 10 0	11	24"–130" dia. 9–39 sq. in. trunk	— —	6×4 16×8
Cyclone dust collector	3′ 6" dia. 12′ 0" ,,	3 9 12 3	5 3 18 10	12	3′ 6"–12′ 0" dia.	—	—
Tubular dust collector	3 8 6 3	5 1 9 6	8 10 8 10	6	60–288 sleeves 3⅛" × 6′ 7"	60	16×3½
Automatic grain weigher	1 7¾ 12 8	1 1¼ 10 0	1 0¾ 8 0	24	Hopper capacity 10–12,000 lbs.	—	
Wheat Washing and Conditioning Machines—							
Wheat stoner,* washer, and whizzer	5 9 6 9	3 7 6 0	5 0 8 1	5	25–40 225–300	600 350	12×6 18×8
Wheat stoner, washer, and rinser	8 9 9 6	2 6 2 6	6 3 6 6	5	40 225–250	107 86	12×3 16×3½
Double wheat washing and stoning plant (maximum clean water, 600 galls. per hr.)	9 6	6 2	7 0	1	200–240	258	24×4½

MACHINES BY MESSRS. THOMAS ROBINSON AND SONS, ROCHDALE (*continued*).

Machine. R	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity. Bushels per hour. Smallest and largest.	Driving pulley. Revolutions per minute.	Size.
Wheat Washing and Conditioning Machines (continued)—	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Vertical ventilated whizzer	3 9 / 6 0	3 3 / 5 6	5 0 / 8 0	5	25–40 / 225–300	600 / 350	12×6 / 18×8
Wheat dryer and conditioner, "C.Hm."	5 0 / 7 3	4 6 / 4 6	17 0 / 35 0	7	40 / 200	42″ fan / 78″ ,,	— / —
Wheat dryer and conditioner "Mallinson's"	3 0 / 4 0	3 9 / 3 9	23 0 / 60 0	7	40 / 200	Fan trunks. 15 sq. ins. / 27 ,,	— / —
Wheat gravimeter or condition gauge	3 8½	0 17	0 22	1	—	—	—
Moisture tester	20 cubic feet / 40 ,, ,,			2	2 compt. / 6 ,,	— / —	— / —
Wheat steaming worm	6 0 / 9 10	4½″ worm / 10″ ,,	—	5	20 / 160	75 / 75	15×2½ / 20×4
Flour-making Machines—					Rolls.	Bks. Reducs.	
Diagonal, four-roller mills. "C.Km."	6 6 / 9 0	3 11 / 3 11	4 11½ / 4 11½	5	13 & 10×30″ / 13 & 10×60″	270 190	20×5
Ditto ditto	Ditto	Ditto	Ditto	5	11½ & 11½×30″ / 11½ & 11½×60″	305 175	20×5
Ditto ditto	9 0	3 11	4 11½	1	10 & 10×60″	350 200	20×5
Bran roller mill	5 9 / 6 9	4 9 / 4 9	5 6 / 5 6	5	15″×24″ rolls / 18″×36″ rolls	180–150	30×6½

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Cyclo-pneumatic separator	4 9	3 8	5 11½	4	—	200	6×4
	7 7½	5 9	9 6			200	8×4
Double-crank plansifter	7 6	8 6	6 3	2	8, 10, & 12 sieves per compt.	382	12×4
	7 6	9 6	6 9			382	12×4
Cyclo-pneumatic dunst separator and purifier	5 6	4 8½	4 6	2	200–300 lbs.	800–900	—
	7 6	4 6	7 9		300–450 lbs	620	—
					Single. Dble. Trip.		
Rotary sieve scalper	8 0	3 6	5 6	3	4 sks. 6 sks. 12 sks.	410	6×4
	8 0	4 6	5 6		6 „ 9 „ 18 „	410	6×4
Single Koh-i-noor sieve purifier	8 2½	4 3	6 6	6	Sieve	520	6×3
	9 8½	4 8	8 0			520	
Double ditto.	8 2½	6 6	6 6	6	Sieve	520	6×4
	9 8½	7 7½	8 0				
Semolina blast purifier	12 9	3 2	4 0	4	Sieve 8″	420	8×3
	12 9	3 10	4 11		20″		
Wood frame centrifugal flour dresser	11 9½	2 6¾	4 4	2	22″ and 30″ dia.	235	13×4
	12 4	3 3	(2½ shts.) 5 2 (2½ shts.)		2, 2½, and 3 shts.	190	16×5½
Iron frame ditto	11 6	2 1	3 6 (2½ shts.)	2	20″ and 27″ dia.	250	12×3
	12 5	2 10	4 2½ (2½ shts.)		1½, 2, 2½, and 3 sheets	210	14×5½
Revolving sifter	7 9	2 1	3 6 (1½ sht.)	5	20″, 22″, 27″, 30″, 35″ dia. 1½–3 shts.	150	10×3
	13 2	3 11	5 2 (3 shts.)			95	16×4
Separating sieve	4 9	3 1½	2 2	4 single 4 dble.	—	520	5×3 5×3½
	8 2	7 1	2 4				
Bran duster	6 9	2 6	3 7	3	4–5 bus.	460	8×6
	10 0	3 2	4 6		15–20 bus.	400	14×9

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MACHINES BY MESSRS. THOMAS ROBINSON AND SONS, ROCHDALE (*continued*).

Machine. (R)	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity. Bushels per hour. Smallest and largest.	Driving pulley. Revolutions per minute.	Size.
	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Flour-making Machines (continued)—							
Automatic flour packer	3 6	3 8	8 9	1	280 lb. sacks.	150	$18 \times 5\frac{1}{2}$
Power driven posser	60 cubic feet.			1	280 lb. sacks.	100	$21 \times 3\frac{1}{2}$
Offal and flour mixer and feeder	1 0	1 7	2 6	2	—	50	8×2
	2 2	1 10	3 8				12×2
Detacher	2 6	0 10	—	4	—	350	10×3
	2 10	1 5	—				13×5
Friction sack hoist	4 6	3 6	2 0	1	—	300	18×5
Combined roll grinding and fluting machine	13 0	6 0	5 0	3	For rolls. 6″–24″ × 40″	182	$20 \times 4\frac{1}{2}$
	17 0	6 0	5 0		6″–24″ × 60″		
Continuous feed elevator buckets (Wade)	length . . . 5″, 6″, 7″, 8″, 9″, 10″, 11″, 12″					For flour 4″ bucket, 25 sacks hour.	
	projection . . . $4\frac{1}{2}$″, 6″, 6″, 7″, 7″, 7″, 7″, 7″						
	tons, hour . . . 20, 30, 40, 60, 90, 100, 110, 120						
Sack shoot.							
Employees' lift.							
Wheat bushelling apparatus.							
Worm Conveyors—							
"Dreadnought" grinder (Barron)	5 9	2 8	3 10	24″ dia. 30″ dia. 2	12–16 bus.	500	$15 \times 5\frac{1}{2}$
	6 0	3 0	4 5		20–24 „	400	18×8
Automatic water-wheel wheat damper	3 6	1 10	3 0	1	—	—	—

Machines by Messrs. E. R. & F. Turner, Ltd., Ipswich.

Machine.	Overall sizes. Smallest and Largest. Length.		Width.		Height.		Number of sizes.	Capacity. Bushels per hour. Smallest and Largest.	Driving pulley. Revolutions per minute.	Size.
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.				Inches.
Dry Wheat Cleaning Machines—										
Cross gear wheat receiving reel, single	9	8	3	6½	4	6 (2 sht.)	3	320 | 24″ 32″	112	15×4
	14	8½	5	7	6	9 (3 sht.)		960 | 42″ dia.	68	24×4½
Single receiving separators	5	2	3	0	4	3	6	50	550	6×4½
	7	10	6	0	6	1		1000		11×5½
Zigzag milling separators	4	9	4	9	6	2½	10	30	520	7×4
	9	9	7	6	8	11½		550		12×8
Scouring and separating machines	5	3½	2	11	3	11½	13	10	700	7×4¼
	11	5	7	6	10	7		600	375	30×12
Horizontal brush finishing machine	5	1	3	6	4	10	9	20	700	7×5½
	9	5	6	3	7	11		250	375	24×12
Combined scouring and separating plant	5	2	4	0	6	0	2	12	150	12×3
	7	5	4	1	6	4		20		12×3
								Barley and Oats. | Cockle.		
Barley and cockle cylinders	5′ 4″ × 14″ dia.						8	5 | 7	15	—
	11′ 1″ × 32″ ,,							37 | 56	6	—
Magnetic separators	1	11	1	7	1	10½	16	15	50	6×1¾
	6	1	1	7	1	10½		340	50	
Wheat Washing, Drying, and Conditioning Machines—										
Concentric washing and stoning machines	4	3	1	6¾	5	2	8	18	9 gals. water min.	
	6	0	3	3½	6	10¾		144	72 ,, ,, ,,	
Vertical whizzer	2	3½	2	1½	8	2½	8	18	460	11×4
	5	1	4	3	10	2		144	260	20×6
Pulsating wheat washer and stoner	11	0	3	10	6	0	3	80	184	24×4½
	11	0	6	0	6	0		280		24×4½
Wheat dryer and conditioner	2′ 6″ dia. × 7′ 6″						2 dias.	32	—	—
	4′ 0″ ,, × 25′ 6″							200	—	—

MACHINES BY MESSRS. E. R. & F. TURNER, LTD., IPSWICH (*continued*).

Machine.	Overall sizes. Smallest and Largest. Length.	Width.	Height.	Number of sizes.	Capacity. Bushels per hour. Smallest and Largest.	Driving pulley. Revolutions per minute.	Size.
	Ft. Ins.	Ft. Ins.	Ft. Ins.				Inches.
Wheat Washing, Drying, and Conditioning Machines (contd.)—							
Turner automatic water-wheel damper	3 7	2 3	3 2	1	—	—	—
Flour-making Machines—						Brks. | Reducs.	
Diagonal four-roller mill	5 3 6 6	4 5 4 5	4′ 1″ 15″×9″ 4′ 1″ 30″×9″	8	15″×9″ 20″, 25″, & 30″	375 | 270	18×4¼
Ditto	6 11 9 5	4 10 4 10	4′ 3½″ 32″×10″ 4′ 3½″ 60″×10″	8	32″, 40″, 50″, & 60″×10″ dia.	350 | 245	18×4¾ 18×5¾
Two-roller mills, heavy pattern for bran	4 9 7 7	2 8 4 2	3 0 4 7	7	15″&18″×9″ 30″ 20″&24″×10″ × 24″&30″×12″ 18″	300 150	16×4 32×8
Hexagonal reels and scalpers	5 7½ 13 1½	1 11 4 4	3′ 3″ 1 sht. ×16″ 6′ 6″ 3 shts. ×42″	4	16″, 24″, 32″ & 42″ dia. 1–3 sheets long	45 21	15×3 45×4
"Vibromotor" rotary scalper and sifter	5 9 9 0	3 6 7 9	4 11½ 6 6	21	3′ × 2′ sieve 6′ × 6′ sieve	260–280	7×2 10×3
Sifters	3 8 7 5½	3 2 3 8	2 6 2 8	3	2′ 6″ × 1′ 6″ 6′ × 2′	500	6×2½ 6×2½
Inter-elevator reels	5 3¼ 14 0	2 4 4 3	3′ 2½″ 1 sht. ×16″ 5′ 10″ 3½ sht. ×32″	3	16″, 24″, 32″ 1–3½ sheets	45 28	15×3 36×4½
Centrifugal flour dresser	6 0 14 1	2 5 3 4	3′ 2½″ 1 sht. ×16″ 4′ 0″ 3 sht. ×24″	2	16″ and 24″ 1–3 sheets	400 260	12×2½ 12×4
Sieve purifier	8 0 11 9	2 9 6 4	4 10½ 7 8	5 sgls. 3 dbls.	sieve 6′ × 10″ ,, 8′×16″&24″	520 520	6×2¾ 6×4
"Semper" air-belt purifier	4 8½ 4 8½	4 5 5 1	5 1 5 1	2	—	260	12×2½
Corn-grinding mills. Two or more pairs in one frame	—	—	—	—	36″, 42″, 48″, & 54″ dia.	180 125	30×6 52×6

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CHAPTER XXXII

GENERAL DATA

Pulley Speeds.—The speed of a pulley is in the inverse ratio of its diameter.

Thus, for example, when a pulley A, 30 inches diameter drives one B of 20 inches diameter, the latter will be the faster. The circumferential speed will be the same in both cases.

If A runs at 100 revolutions per minute, B runs at $3 \times 50 = 150$ revolutions per minute.

Foreign Weights and Measures.—The metrical system has been adopted in France, Belgium, Netherlands, Switzerland, Germany, Italy, Spain, Portugal, Greece, Austria, Sweden, and Norway. Other countries will probably follow. In view of this, it will be profitable to investigate the relation it bears to the English "system" (so-called).

Linear Measures.

1 millimetre	=	0·03937 inches	= $\frac{1}{32}$", $\frac{1}{64}$" −
1 centimetre	=	0·393704 "	= $\frac{3}{8}$"; $\frac{1}{64}$" +
1 decimetre	=	3·937043 "	= $3\frac{15}{16}$"
1 metre	=	39·37 "	= 3−3$\frac{3}{8}$ feet.
1 decametre	=	393·7 "	= 32 feet − 9$\frac{11}{16}$, $\frac{1}{64}$ +
1 hectometre	=	3937·043 "	= 328 feet − 1$\frac{1}{32}$ $\frac{1}{64}$ +
1 kilometre	=	39370·43 "	= 3280 feet − 10$\frac{7}{16}$" −
1 myriametre	=	393704·3 "	= 6 miles 1128 feet 8$\frac{5}{16}$" +

1 inch	=	0·02539954 metres.
1 foot	=	0·3047945 "
1 yard	=	0·91438348 "
1 mile	=	1609·3149 "

Square Measures.

1 square inch	=	0·000645137	square metres.
1 square foot	=	0·09289968	" "
1 square yard	=	0·836097	" "
1 square mile	=	2589894·5	" "

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Cubic Measures.

1 cubic inch = 0·00001638 cubic metre.
1 cubic foot = 0·0283153 ,, ,,
1 cubic yard = 0·764513 ,, ,,

1 gill = 0·141983 litres
1 pint = 0·56793 ,,
1 quart = 1·13586 ,,
1 gallon = 4·543457 ,,

1 peck = 9·086915 litres
1 bushel = 36·34766 ,,
1 quarter = 290·7813 ,,

Weight.

1 ounce avoirdupois = 28·349375 grammes.
1 pound ,, = 453·59265 ,,
1 cwt. ,, = 50802·38 ,, 50·80 kilos.
1 ton ,, = 1016047·5 ,,

1 kilo = 2 lbs. 3·2 ozs. approx.
5 kilos = 11 lbs. approx.

Other measures are:—

1 centner = 110 lbs., approx. Germany.
1 pood = 36 lbs., approx. Russia.
1 chetwert = 5·75 bushels, approx. Russia.
1 oke = 2·75 lbs., approx. Greece, Turkey.
1 quintal = 123 lbs., approx. Greece. / 125 lbs., approx. Turkey.
1 pund = 1·102 lb. approx. Denmark.
1 skålpund = 1 lb., approx. Sweden.
1 kanna = ½ gallon, nearly. Sweden.

ENGLISH MEASURES

Linear.

12 inches = 1 foot.
3 feet = 1 yard.
6 feet = 1 fathom.
5½ yards = 1 rod, pole or perch.

4 poles = 1 chain (22 yds.).
40 rods = 1 furlong.
8 furlongs = 1 mile (1760 yds.)

Square.

144 square inches = 1 square foot.
9 square feet = 1 square yard.
30¼ square yards = 1 square rod, pole or perch.
160 square rods = 1 acre.
640 acres = 1 square mile.

Cubic.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.

Avoirdupois Weight.

16 drams = 1 oz.
16 ozs. = 1 lb.
28 lbs. = 1 quarter.

4 quarters = 1 cwt.
20 cwt. = 1 ton.

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DRY MEASURE.

2 gallons	= 1 peck.	3 bushels	= 1 sack.
8 gallons	= 1 bushel.	12 sacks	= 1 chaldron.

MEASURES OF CAPACITY.

4 gills	= 1 pint.	8 gallons	= 1 bushel.
2 pints	= 1 quart.	8 bushels	= 1 quarter.
4 quarts	= 1 gallon.	5 quarters	= a load.
2 gallons	= 1 peck.		

1 gallon water = 10 lbs.

Wheat Measures.—One of the most unsatisfactory measures in use in England amongst millers and grain merchants, is the "quarter." The quarter favoured by the Government is the 480 lbs. measure. Mark Lane 504 lbs. Russian wheat is often sold at 492 and 496-lb. qtrs. American wheat from the Atlantic seaboard is sold in 480 lb. qtrs., and from the Pacific coast at 500 lbs.; these matters are further complicated by the fact that the weight of any particular wheat is the best index to its value. The quarter is not a trustworthy measure in this respect. The best solution of the difficulty would probably be the adoption of the cental or hundred-pound measure. The "Corn Returns" Act of 1882 fixed the wheat bushel at 60 lbs. The barley bushel at 50 lbs. and the oat bushel at 39 lbs.

CORN WEIGHTS AND MEASURES USED ON CORN MARKETS IN THE UNITED KINGDOM.

1 quarter	= 8 Imperial bushels.
,,	= 492–496 lbs. of foreign wheats.
,,	= 480 lbs. London market foreign wheats.
,,	= 504 lbs. English wheat.
1 coomb	= 4 Imperial bushels.
1 load	= 3 ,, ,,
,,	= 5 ,, ,,
,,	= 5 quarters.
,,	= 144 quarts.
1 boll	= 2 Imperial bushels.
,,	= 3 ,, ,,
,,	= 6 ,, ,,
1 bushel	= from 57 to 80 lbs. (average 60), according to weight of grain, the measure being 1¼ cubic feet.

1 cental	= 100 lbs.	1 windle	= 220 lbs.
1 cwt.	= 112 ,,	1 boll	= 240 ,,
1 ton	= 2240 ,,	1 barrel	= 280 ,,
1 bag	= 190 ,,	1 sack	= 240 ,,

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CHAPTER XXXIII

EXAMINATION QUESTIONS

In dealing with a few of the examination questions set annually by the City and Guilds of London Institute in conjunction with the National Association of British and Irish Millers, the author desires to point the fact that they are set by expert millers, who have the latest milling information and developments at their disposal. Therefore matters discussed will indicate the modern trend of milling science. Where possible, reference is made to the sections of the book dealing with each. The syllabus following is typical of the courses of instruction followed by lecturers on flour milling at the various technological centres.

MILLING (FLOUR MANUFACTURE).

Ordinary or "No. 1" Grade.

Syllabus.

1. Structure and composition of the wheat berry, with brief history.
2. Varieties of native and foreign wheats under headings of weak, medium, and strong, with character, qualities, percentage of impurities and flour yield. Times of harvests.
3. Brief history of flour milling.
4. Handling and storage of wheat, with preliminary cleaning and aspiration.
5. Wire, perforated zinc and other screening mediums.
6. Wheat cleaning, (*a*) wet, (*b*) dry, with conditioning in each case—Machines and processes up to date—Handling and disposal of screenings.
7. Blending and mixing wheats.
8. Simple "flow-sheets," illustrating reasons for travel and treatment of stock, from clean berry to the finished flour in the gradual reduction system.
9. Roller mills, principles of construction, speeds, differentials, groovings, application of pressure, exhausting and its uses, driving, lubrication, and power required—Methods of, and rules for, working.
10. Grit-gauze, and silks used for grading and dressing.
11. Scalping and grading—Machines used and methods of

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operating—Principles of construction, speeds, clothing, operation, and power required.

12. Purification—Machines and systems—General principles of construction and handling, clothing, speeds and power.

13. Flour dressers—Machines—Principles of construction, operation, clothing, speeds, and power.

14. Transmission of power, elevators, band and spiral conveyors, lifts, hoisting tackle, shoots, dust-collectors, and all appliances needed in modern flour mills.

15. Flour tests and bleaching methods.

16. Storage of flour and offals—Reasons for systems adopted.

17. Current world's wheat-crops with main features.

Honours or "Final" Grade.

Syllabus.

1. The wheat berry with chemical constituents and properties —Harvests.

2. Prices and all particulars of current wheats.

3. Wheat mixtures, mixing and blends—Combinations of wheats requisite to produce flours of certain defined qualities giving best baking results.

4. Handling, storage, and dry cleaning of wheat-machines and flows, with history of flour milling.

5. Dust collecting and dust exhaust plants.

6. Washing, steaming, and conditioning machines and flows.

7. Roller mills for breaks and reductions, all particulars of operation.

8. Scalping, ordinary and pneumatic systems with grading for purification.

9. Purification, principles involved, coverings and methods of operating machines and systems.

10. Flour dressing—Machines used—Features of various types.

11. Flour tests and baking—Bleaching—w th chemical and other effects upon flour treated.

12. Designing flow-sheets—complete or sectional.

13. Preparation of products for sale—Flour dividing and blending —Offal sorting—Warehousing.

14. Mill Manager's work—Collecting and keeping mill records—Percentages—Cost of production.

15. Automatic sprinkler systems—Fire insurance.

16. Lighting and ventilation of flour mills.

17. Power required and power-producing plants.

18. Planning, construction, and equipment of intake plants, silos, mill buildings and warehouses—in both machines and operatives.

19. State of wheat, flour and offal market up to end of session.

Ordinary Grade, 1911.

1. Describe briefly the milling quality of each of the following wheats from the 1910 crop: No. 2 N. Manitoba, North Russian, South Russian, Danubian, Australian, C. W. Kurrachee, Red English (ordinary), Red English (Fife).

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Ans.—*No. 2 N. Manitoba* contained a quantity of thin and frosted grains, the rather dry season and sharp early frosts being responsible. Flour yield rather below average; strength fair. *North Russian.*—Above usual standard both as regards strength and colour. Supply short; all parcels were readily bought. With careful cleaning, washing and conditioning, it yielded excellent semolina, middlings, and fine free stock. *South Russian.*—Good quantities available, but full of very thin grain and impurities. This resulted in poor flour yields mainly. Although with efficient conditioning the strength was a good average in most cases. *Danubian.*—An all-round average, used mainly for "padding" the mixtures. It had no special outstanding features, being mild, yielding good quality of bran, but not to be relied on for any sharp stock. *Australian.*—Rather full of chaff, but of first-class colour. Dry, and somewhat apt to absorb water too readily. As usual had a ready sale at good prices because of the fine bloom it imparted to the flour and the loaf. *C. W. Kurrachee.*—This Indian wheat hardly justified its name of "choice white," as its flour came out rather dull, tending in some cases to almost a yellow tint. Parcels were plentiful; special care had to be exercised in the screen-room by steaming and washing to soften the dry and somewhat "brittle to flinty" nature of the grain. The strength quality was an uncertain one, and millers putting faith in it upon the test of one parcel were disappointed in a later consignment. *Red English.*—An uneven crop. East, south and west the crops and flour yields were good. North they were bad. As usual the bran was good and the taste excellent. But, milling soft, it had to be used in moderation. *Red English (Fife).*—Rather too soft, although one of the best native wheats. Quantities available not sufficient to cause the use of excessive percentage in the mixtures. A fine flavour and fair strength.

ORDINARY GRADE, 1911.

2. Explain the practical application of any reliable moisture-testing apparatus as an adjunct to modern milling. State how you would make such experiments, writing full details of one moisture test made on Ros. Fe Plate wheat of 58–60 lbs. weight.

Ans.—The moisture tester already described on pages 113–15, Fig. 56, is a good example of the mechanism now employed for scientifically determining the amount of water contained in wheat, whether in its natural condition or after conditioning. The test upon Ros. Fe Plate wheat of the weight given would be as described, but special care would be necessary in order to avoid burning or overstepping the limits of moisture extraction only, this wheat being thin and rather dry, judging by the figures given.

ORDINARY GRADE, 1910.

3. Specify wheat-cleaning machines in which air separations are made. Describe how the extraction of refuse is effected. Any causes of failure in operation to be clearly stated.

Ans.—Aspiration plays a deservedly important part in the dry-cleaning plant. Every separating, screening, and grading

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machine should be fitted with exhausts. The list comprises: rubble reels, warehouse separators, zig-zag separators, rotary graders, cockle and barley cylinders, brushes and scourers, aspirators (devoted entirely to this one object). All points on the handling plants should be aspirated, where the dust is disturbed. In order to allow the air suction to have the greatest effect in removing impurities, the grain should be spread out in a broad thin stream at the line of application. Large quantities, travelling fast, are practically a wall through which the air current will not pass. In most machines, the principles involved are the same, namely application at (1) feed, and (2) delivery. Scourers and brushes in addition are strongly aspirated through the perforated case, in order to remove the loosened impurities. The dust-laden air current leaving the wheat streams, through which it has been made to pass at its maximum speed, by contraction, in order to obtain the greatest lifting capacity, must be induced to deposit its burden before reaching the fan. This is done by passing it through chambers and trunks of different areas. Expansion lessens the carrying power of a draught, and the various screenings are deposited in several screenings "tips" according to their respective weights. Causes of failure are slipping belts and dropping speeds of fans, badly set valves, clogged air passages, insufficient air ingress following upon badly crowded machines. Baffled exhaust caused by fan discharging into a choked dust collector. Back-pressure to any appreciable extent must be carefully avoided. (Figs. 25, 27, 37, 43, 44, 45, will supply all necessary descriptive sketches).

ORDINARY GRADE, 1909.

4. Describe an economical and practicable method of cleaning English wheat containing smut and garlic, complete preparation for milling to be indicated.

Ans.—The most essential point in dealing with impurities of this nature, is to remove them as gently and in as whole a condition as possible so that the mischief of discoloration and taint does not spread. Powerful aspiration on the dry-cleaning plant is the most successful in both cases, and careful treatment on the scum tank of a washer will float away the greater part of the remainder. The two troubles named are the most serious which the miller has to encounter in cleaning native wheats. Some advocate scouring and brushing before washing for removing smut, but this is a doubtful benefit. The evil being, in most cases, multiplied. Garlic, being almost the same size and shape as wheat, is most difficult to eliminate and at the best the separation is imperfect. The point to remember is that it will absorb and part with more moisture than wheat. Therefore whilst treating on the dryer the remaining garlic bulbs can be dried at a greater rate than the wheat grains, thus being rendered appreciably lighter, especially if passed slowly through with the application of strong warm air currents, placed in the blending bins for 24 hours, and then treated to a strong brushing and aspiration before passing to the breaks. The odour of garlic clings to the wheat in a most persistent way, and with all this care it often happens that the bread just out of the oven gives off the

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familiar reek. This, however, will finally evaporate as the bread cools. Badly tainted parcels should be left severely alone.

ORDINARY GRADE, 1907.

5. Draft a diagram, placing every machine in its correct position in the cleaning plant for a mill with a flour capacity of 35–40 sacks per hour. If you adopt any machines in duplicate, give practical reasons for such provision.

Ans.—Assuming that the cleaning plant was running day and night, the capacity of the plant would be, taking the maximum output of the mill at 40 sacks and a 70 per cent. flour yield—

$$\frac{40 \times 2 \times 10}{3} = \frac{800}{3} = 266 \text{ bushels per hour,}$$

or = 33 quarters per hour (say 36 quarters). It would be wise to increase this by 10 to 15 per cent. to allow for surplus and screenings; as the mixture would probably be a wide one, it would be advisable to split this, using two separate cleaning plants of, say, 16–18 quarters per hour each. If there is any danger of stoppages, through water shortage on the washing plant, or delays through retreatment of parcels of stubborn wheats, it will be safer to use two 20-quarter plants, so as to keep well ahead of the mill. An additional advantage of the two plants would be the ability to treat widely differing wheats separately, both cleanings could then be run together and become assimilated before feeding to the breaks. All wheats would be treated over the usual dry-cleaning machines, and would pass to their respective washing and conditioning plants. The harsh and flinty wheats, would be well washed and left to soak after being whizzed. The brittle would be steamed and then washed and whizzed and conditioned. The rest of the mixtures, the moderate qualities of grain, would be treated to washing, whizzing and drying and conditioning in the ordinary way. The harsh and flinty wheats could be run in with these in smaller quantities for an extra washing and conditioning; all the separately treated wheats of the mixture could then be run together as indicated in Fig. 48.

GRADE I, 1912.

6. What is your opinion of pneumatic scalping, and how do you consider it affects the working of a roller mill compared with ordinary scalping? Sketch some type of pneumatic scalper with which you are acquainted.

Ans.—The use of air currents alone in dividing the wheat skins from the freed semolina, midds, etc., is a delicate operation, demanding for profitable results, clean, sharp stock and wheats. The whole process, as in purification, consists of a "weighing" by air, and as such is hampered in the presence of soft, clinging and dusty stock. If the wheat and stock are in the best condition for this class of scalper, the feeds to graders and purifiers, will be finely sorted and some high-class reduction patents may be expected. A higher class of break flour should follow upon the gentle treatment and the minimum abrasion of stock. The purifiers should

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be worked with clean stive chambers, and the trays will contain the minimum of deposit. Brighter flour should be expected all round. On soft, damp mixtures, or on very dry and brittle wheats, the sifting form of scalping will show to advantage, it having a wider scope, although not so perfect in theory. The work of the pneumatic scalper being so finely balanced, the operatives must carefully regulate feeds and pressures to rolls and adjust the aspiration to all the break systems to meet altering conditions. Fig. 77, page 160, will answer the latter part of the question.

ORDINARY GRADE, 1910.

7. State the various ways in which the work of a sieve purifier may be affected and explain how in each case you would deal with the difficulties named in your answer.

Ans.—First of all, a purifier of the sieve type must have a feed within a moderate range of numbers, for efficient work, in providing well-graded and dusted stocks to the following reductions. The excellent work of a long range of purifiers as used in a large mill is evidence of this. Here the grading system has to deal with large quantities of stock. Dividing and sub-dividing to an elaborate extent are here possible, each grouping of a small range of sizes providing ample feed for one purifier. In smaller mills this is not possible and the range of size necessarily goes up, to the detriment of the purification. (1) Hard, coarse, and free stocks are one extreme; (2) soft clinging fibrous stocks are the other. The best work is therefore done upon three medium sizes of midds, from fairly hard, moderately dry wheat mixtures. In treating (1) the danger is that it will rush too quickly to end of sieve and tail away stock which should have graded through. The chief trouble will therefore be to keep the eccentrics running as truly as possible in order that sieve may show no tendency to "jump." Careful adjustment of the hangers will help. The wind currents will not give trouble in this case with moderate application. No large amount of tray deposit will be made. Soft stock, such as (2), will refuse to grade through, especially if from a somewhat damp mixture, because of its tendency to mass together. Aspiration must be carefully adjusted as that the trays are not full of good pure stock. Brushing will be necessarily thorough if the sieve is to be kept clear. Stock will tend to bunch and hang, therefore sieve must be level in cross-section. Evenly spread feeds, well designed covers, thorough cleaning and exhausting, smooth running, are amongst the most important points to be dealt with in successful purification. Atmospheric changes, so damaging to the work of these machines, must be fought by the operative as his skill and experience guide him.

ORDINARY GRADE, 1908.

8. Draw a diagram showing the full break system process you prefer for either 10-sack or 20-sack plant. The diagram is only to include break rolls and necessary scalping machines, but all speeds, sizes, and groovings of rolls must be plainly shown.

Ans.—The Fig. 84 gives a suitable flow for a 20-sack plant

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and all speeds, etc., will be found. From the many systems favoured. The plansifter is the machine chosen, although some excellent work is also done upon rotary graders, reels, and the cyclo-pneumatic system of scalping.

Ordinary Grade, 1906.

9. Do you prefer rollers of 24, 30, 36, or 40 inches for dunst and fine middlings reductions? Give your reasons for choice, showing full appreciation of all considerations involved in the selection of rollers. See Chapter XXIII, pages 196–202.

Grade I, 1912.

10. In a 10-sack plant, generally accustomed to grind wheats containing 16 per cent. of moisture, it is desired to grind 500 sacks of flour from a grist containing only 14·5 per cent. of moisture. State what adjustments you would make, in order to produce flour of the highest possible colour, not less than the normal percentage of flour to be obtained.

Ans.—The mill is normally grinding a somewhat damp mixture, and will therefore be grinding fairly heavily and dressing slightly coarsely. The slight excess of damp in the stock will keep the flours free of greys and specks, and the work of the scalping, grading and purifying will be somewhat heavy. To change the mixture to the dry 14·5 per cent. mixture condition will mean free and somewhat dusty stock all round. The difficulty will not be to keep up the yield, so much as to preserve the flour from becoming specky and damaged in colour. Some pressure would have to be removed from the breaks, higher grinding being the only safe way to avoid an excess of fine stock and break flour. Care would be necessary on the bran-cleaning roll to avoid shattering it (the bran), whilst removing the adhering endosperm. Thorough aspiration and gentle treatment on the scalpers and graders will keep down the attrition of stock, so natural upon dry mixtures. It may be found necessary to change a few of the dusting sheets for a finer number to preserve the break plan in a pure state. Special attention must be paid to the scratch system, as the above treatment will provide more feed for it. The greater part must be returned to the head of the reduction system. All the wind valves must be finely adjusted on the purifiers. The tray deposits will probably be heavy. With careful working it will be possible to keep the stocks at the head of the reductions. The neglect of any of the above measures will result in overcrowding the latter reductions with dusty inferior stock. On the other hand, all machines, especially if centrifugals are used for dressers, must be well fed to avoid the defect of bare covers—greys in the flour.

Final Examination, 1912.

11. Enumerate the points in the reduction system of a mill, having reductions from A to L, and two scratch systems, where

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loss may occur both in percentage of flour obtained and in the quality of the resulting flour, by reason of too close grinding. Describe fully how this loss and deterioration would be caused.

Ans.—Close grinding means large quantities of small stock at the expense of the semolina percentage on ordinary mixtures. At once trouble will be experienced in scalping, grading, and dusting. Scratch stock being essentially large stock (*i.e.* large semolina with adhering bran snips), the supply to the system will be largely diminished so that the resulting flour dusted away from the scratch will be small and poor in quality, the feeds from scratch to the first reductions will likewise be small. Very close grinding will powder an abnormal amount of bran, so that it will contaminate the fine stock, among which it will mingle, instead of tailing away to offal. Although the large amount of break flour made would tend to be of an improved colour, this will be counteracted by the fine bran powder. On the reduction system, one section will lose in both colour and quantity, whilst the other will gain in quantity, but lose in both strength and quality and colour. To take A and B reductions, these are fed by the coarse and medium semolinas. The feeds to their purifiers being reduced, the rolls will naturally yield decreased flours and tailings feeds to the following C rolls. The patents flour will be at once crippled in amount and quality. Further down the mill on, say, G, H, J, the stocks will have crowded from the overfed fine midds and dunst purifiers. They will be indifferently graded and purified, and will yield large quantities of poor-coloured flour. The feed to the last reductions will be badly muddled and will result in large percentages of offals of too rich a nature, at the expense of lost flour.

12. Give a full account of the changes that take place during the fermentation of flour by yeast in the process of making bread, and describe in full detail any test you know, other than the baking test, that gives a reliable indication of strength in flour. What do you understand by the term "strength" as applied to flour?

Ans.—When flour has been doughed up and has, incorporated in its mass, the necessary salts and yeast and water, etc., a process of fermentation or growth of the yeast plant is taking place within and around the starch and gluten cells, forming the main bulk of the dough. The heat in the oven, in baking, causes the mass to rise, by rendering the yeast agencies extremely active and by inflating the innumerable minute starch and gluten cells. After a time the heat will have coagulated the gluten and other nitrogenous compounds. The moistened starch of the dough is gelatinized, the surplus moisture is driven off along with a certain amount of alcohol, acetic acid being formed at its expense. The yeast and bacteria, living their short term, are killed by the moist heat, and the result is a bread food thoroughly sterilized. On the surface the dough becomes changed, and a proportion of dextrines is found, thus "glazing" the loaf (*i.e.* "crusting" it). The best test of strength is that the gluten cells expand evenly and hold against the tendency to burst from the pressure of the expanding gases. If they can do this for the period of baking (from 50 to 70 minutes), at approximately 500° F., then the gluten is of good quality and the flour strong. A high-piled loaf of good shape and texture will result. Reference to Chapter XXV, pages 209–12, will give the other tests

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for strength. The best definition for "strength" in flour is that just supplied in describing fermentation and baking.

Milling Examinations.—In answering examination questions the most successful student is the one who has trained himself to express matters simply and clearly, and who draws upon the experience and theory underlying them. In studying the foregoing chapters with a view to sitting for examination, the author advises a careful recapitulation of all the main features. The purpose and skeleton of each machine and system should be memorized, and a *personal* interpretation of all matters made. Main principles must be thoroughly grasped. All advances made must be noted by the student.

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